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# Biological Effects of Nonionizing Electromagnetic Radiation

VOLUME 1

NUMBER 3

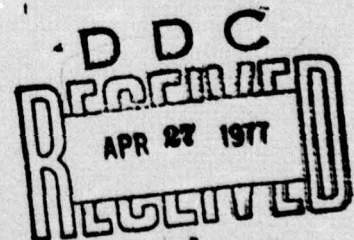
APRIL, 1977

## A DIGEST OF CURRENT LITERATURE

A Quarterly Publication  
Produced for  
Office of Telecommunications Policy  
and  
United States Navy

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A Digest of Current Literature.

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Literature Selected and Abstracted  
by

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# BIOLOGICAL EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION

April, 1977 Volume 1, Number 3

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## PREFACE

*Biological Effects of Nonionizing Electromagnetic Radiation* is a publication researched and prepared by the Franklin Institute Research Laboratories, Science Information Services Department, under a contract with the U.S. Navy and administered by the Office of Telecommunications Policy.

This digest serves as a vehicle through which current documentation of research highlights on the biological effects and health implications of nonionizing electromagnetic radiation (microwave and radiofrequency radiation) are compiled, condensed, and disseminated on a regular basis. *Biological Effects of Nonionizing Electromagnetic Radiation* is intended to be a highly useful current awareness tool for scientists engaged in research or related activities. The great number and diversity of relevant publications make imperative the availability of this service to persons whose work requires that they keep abreast of current developments in the field.

*Biological Effects of Nonionizing Electromagnetic Radiation* is published quarterly. The issues of Volume I, and future volumes, will include materials received during the preceding three months. Each issue will include news items and announcements, a listing of meetings and conferences, abstracts of current literature, and a directory of current research. Materials for which full text is not available will be included as summary abstracts.

## ABBREVIATIONS AND ACRONYMS

A, amp - ampere(s)	n - nano--
BRH - Bureau of Radiological Health	NBS - National Bureau of Standards
C - centigrade	NIH - National Institutes of Health
cm - centimeter(s)	NSF - National Science Foundation
cps - cycles per second	NIOSH - National Institute for
dB - decibel(s)	Occupational Safety and Health
EPA - Environmental Protection Agency	NTIS - National Technical Information
FDA - Food and Drug Administration	Service
g - gram(s)	Oe - oersted(s)
G - Gauss	OSHA - Occupational Safety and Health
GHz - gigahertz	Administration
HEW - Health, Education, and Welfare	OTP - Office of Telecommunications
hr - hour(s)	Policy
Hz - hertz	PHS - Public Health Service
IEEE - Institute of Electronic and	rad - radiation absorbed dose
Electrical Engineers	R - roentgen(s)
IMPI - International Microwave Power	rpm - revolutions per minute
Institute	sec - second(s)
IU - international unit(s)	USAFSAM - U.S. Air Force School of
J - joule(s)	Aerospace Medicine
k - kilo--	USDA - U.S. Department of Agriculture
l - liter(s)	UV - ultraviolet
m - meter(s)	V - volt(s)
m - milli--	VA - Veterans Administration
M - mega--	W - watt(s)
mho - unit of measurement of	WHO - World Health Organization
conductivity	wk - week(s)
min - minute(s)	wt - weight
mo - month(s)	yr - year(s)

## NEWS ITEMS

### GE MICROWAVE OVEN CORRECTIONS TO BE MADE

The Bureau of Radiological Health in early January approved the General Electric Company's plan to correct potential microwave leakage problems in GE "Versatronic" and Hotpoint "Cook Center" microwave ovens manufactured since November 1973. The corrective action program is scheduled to begin by February 1, 1977. A year ago, the Bureau found that some of the ovens were leaking microwaves in excess of the limit permitted by the Federal performance standard. In October 1975, the Bureau informed General Electric of the noncompliance and directed the firm to submit a corrective plan. The company contested the Bureau's finding at a Food and Drug Administration regulatory hearing. The Agency upheld the Bureau. General Electric then requested an exemption from the notification and repair requirements; the Bureau denied the request on the grounds that the company's evidence was insufficient to prove that the noncomplying ovens create no significant risk of injury and again asked the firm to submit a correction plan. The plan was submitted in September 1975 and approved by the Bureau. According to the Bureau-approved plan, General Electric will manufacture modification kits and train service personnel to install the new parts. Owners will be notified by letter and also will be sent a customer brochure explaining the problem and the nature of the repairs. The modifications will be made in owners' homes at no cost to consumers. The company estimates that repairs will be completed by December 31, 1977.

*BRH Bulletin* 11(1): 1; 1977.

### HIGH VOLTAGE EFFECTS ON ANIMALS TO BE STUDIED

The Electric Power Research Institute (EPRI) and the U.S. Energy Research and Development Administration (ERDA) are cosponsoring a two-year, \$2.3-million project to study the effect of exposure to electric fields from high voltage (HV) transmission lines on animals. EPRI project manager for electric field biologic effects, Dr. Harry Kornberg, explains that EPRI will study electric field effects on large animals. EPRI has awarded a \$1.1-million contract to Battelle, Pacific Northwest Laboratories, to investigate the possible biologic effects on Hanford miniature swine of long-term exposure to electric fields of 30 kV/m. This is equivalent to a 15-kV/m exposure for a human, which is almost twice the field intensity anybody would be exposed to from transmission lines in the U.S. A number of studies have been conducted recently both in the U.S. and abroad in response to concern that exposure of humans to HV electric fields may have harmful biologic effects. The experiments at Battelle will involve 40 swine kept in four modules with electrodes activated on a 24-hr basis in addition to a control group of 20 swine. An interdisciplinary team of scientists will monitor the experiment. ERDA, companion sponsor in the project, will be

studying the effect of HV transmission lines on small animals, such as, rats, mice, and hamsters.

*Transmission & Distribution* 28(12): 12; 1976

### BUREAU'S MICROWAVE AND RF PROGRAMS REVIEWED AT SYMPOSIUM

A symposium on the Bureau of Radiological Health's current in-house and extramural activities in the area of microwave and radiofrequency research was held February 16-18, 1977 at Bureau headquarters in Rockville, Maryland. The Symposium on Biological Effects and Measurement of Microwave and Radiofrequency Sources was the second in a series of meetings the Bureau has convened to bring together all Bureau personnel, contractors, and grantees working in a single program area to exchange information on their research and to review the status of ongoing projects. The agenda for the February 1977 symposium included presentations on the genetic and somatic effects of human and animal exposure to various levels of microwave radiation, microwave and radiofrequency measurement instrumentation and techniques, and the health implications of occupational exposure. The proceedings will be published as a BRH report.

*BRH Bulletin* 10(22): 3; 1976

### SEMINAR ON MAGNETIC FIELDS AND ORGANISMS

A seminar was held in November, 1975, on the effect of magnetic fields on organisms; it was organized by the Faculty of Electrical Engineering of the Technical University of Prague. The presented papers dealt with the physical laws of the formation and measurement of magnetic fields and the effect of magnetic fields on biologic processes in organisms.

*Cesk. Cas. Fys.* 26(3): 319-320; 1976

### ROBINS NEED MAGNETIC NORTH TO FIND THE STARS

Investigators at the University of Frankfurt previously reported that birds seemed to use their magnetic compass "even if other cues were present and that the magnetic information possibly overrode to some extent the other systems." Recently, "As a test of this hypothesis, they kept some migratory robins underneath an artificial starry sky in a magnetically screened room. The migratory tendency, measured by the perching time in each part of the cage, was randomly scattered. When they applied an artificial magnetic field of the same intensity as

## NEWS ITEMS

*Biological Effects Nonionizing Electromagnetic Radiation 1(3), April 1977*

that of the Earth, a flutter trend in the normal migratory northerly direction immediately evolved. The next night, in the absence of the magnetic field and under the same sky, which first gave a random scatter, the northerly trend was maintained just as strongly. It seems that the robins are able to label the stars in the same way, given a magnetic north, as we label a landmark using a compass and then manage without the compass."

*New Scientist 71: 642; 1976*

## MILLIMETER WAVE TISSUE SPECTROSCOPY

Using available millimeter waveguide equipment and components, a special waveguide cell has been developed for making millimeter wave measurements on tissue samples and cell suspensions. Preliminary tests conducted by Dr. Om Gandhi with a cylindrical pipet tissue holder have not produced striking differential absorption effects. However, tests will be performed with the new sample holder in an attempt to duplicate selective absorption effects (tumor versus normal cells) reported in the literature.

*Utah Bioengineering Newsletter 4(1): 1; 1976*

## MAGNETIC DIRECTION FINDING IN MIGRATORY INDIGO BUNTINGS

An investigation was conducted to study the orientational capabilities of caged migratory indigo buntings under differing magnetic field conditions. "When tested in a situation allowing minimal exposure to visual cues but in the presence of the normal geomagnetic field, the birds demonstrated a significant orientation in the appropriate migratory direction (to the north)." The authors report that when the "horizontal component of the magnetic field" was deflected, the orientation of the bunting shifted accordingly. They conclude that "Indigo buntings are not only able to detect the geomagnetic field, but also can use this information in the finalization of their migratory direction."

*Science 193: 505-508; 1976*

## PANEL DISCUSSION ON MICROWAVE SAFETY AND HAZARDS

Included in the agenda of the 1976 Microwave Power Symposium was a panel discussion on microwave safety and hazards chaired by Dr. Sol Michaelson of the University of Rochester. Various considerations required for microwave safety hazard assessment were discussed. It was suggested that in any discussion

of microwave safety hazard assessment, the definitions of such terms as biologic effect, hazard, and standard are required. In addition, important concepts of threshold, cumulative effect, and adaptation must be considered. The laboratory environment for experimental animals and the real-life situation for man, which includes the clinical evaluation and epidemiologic assessment, have to be kept in perspective. Of considerable importance is the question of extrapolation; this requires consideration of physical scaling by size, volume, and wavelength in relation to physiologic scaling for interspecies comparison and extrapolation to man. In a discussion of standards or protection guides, it is important to consider personnel exposure standards in relation to occupational exposure standards, including the military. In some countries the military is not subject to the constraints as are other occupational groups. The discussion also touched on whether a separate standard is required for the general population vis-a-vis workers. The relation of product emission standards in contrast to personnel exposure standards was noted. The question of international standards and whether uniform standards on an international basis can be developed were also discussed.

*Microwave Energy Applications Newsletter 9(5): 6-7; 1976*

## HAD YOUR RADIATION DOSE TODAY?

With all the discussion about pollution of the environment, very little attention has been focused on radiofrequency radiation as a possible health hazard, according to Frederic B. Jueneman, director of research for Integrated Navigation and Communications Automatics (INCA). Jueneman states that twentieth-century man has had "to undergo continuous exposure to electromagnetic radiation where the broadcast spectrum of quarter- and half-wave lengths spans our growth cycle from infants to adults." Although the evidence on subliminal broadcast energy as a health hazard is conflicting, Jueneman cites a case from a Texas metropolis where a person of unusual sensitivity was nervously affected in some urban areas and not in others. This peculiarity was traced in part to FM reception and the variability of signal strength throughout the city. This individual was most affected in a horizontal position, so that it might be assumed that the body-antenna was receiving a planar wave, of the sort used for reception of FM or TV broadcasts. Jueneman points out that the height of children (between 0.5 and 1.5 m) makes them particularly receptive to wavelengths (full, half, and quarter) of 50 to about 600 MHz—the wavelength range of TV-FM channels well into the ultra high frequency region. For adults whose heights range from 1.5 to 2 m, there is a little more selectivity that confines them to the very high frequency band, which ranges from around 37 to 200 MHz. Jueneman concludes that "There may be several alternative and perhaps more effective means of

communication on the horizon [e.g., cable or light pipe communication], but until then we can bask in the 'radio-active' wastes of twentieth-century civilization and take our daily dose of inspiring messages."

*Industrial Research* 18(2): 9; 1976

smaller animals is described by a numeric field theory technique, but results are only partially available near the resonance region for the man model. This research was sponsored by the School of Aerospace Medicine, Brooks Air Force Base.

*Utah Bioengineering Newsletter* 4(1): 1; 1976

#### BRITISH STUDY EXPLORES RADIATION HAZARDS

The proliferation of high-power troposcatter communications systems in England has led to a comprehensive study to define radiation hazard zones associated with antennas propagating nonionizing energy. A report by D. H. Shinn indicates that a typical tropo installation has a biologic hazard zone that extends 1 km or more from the antenna. Shinn developed an easy-to-use graphic method for locating the approximate boundaries of danger zones for biologic damage, ignition, and detonation. The curves are based on the peak and average radiated power, and the size and gain of the antenna; all data are referenced to the accepted biologic hazard level of 100 W/m<sup>2</sup>. A threshold for detonation depends upon the material in question. Circular, elliptical, and rectangular antenna apertures are covered, along with the phenomenon of ground enhancement, which may be as high as 6 dB.

*Microwaves* 15(12) 30; 1976.

#### HIGH POWER MICROWAVE GENERATOR

A 750 W, 915 MHz microwave generator has been completed for use in microwave hyperthermia research. The system will be used for studies of localized tissue hyperthermia with different types of microwave applicators. In addition, the generator will be used in rewarming infants after hyperthermic surgery, in localized hyperthermia in mice for cell sensitization studies, and in hyperthermic cell culture research.

*Utah Bioengineering Newsletter* 4(1): 1; 1976

#### MICROWAVE DOSIMETRY HANDBOOK

Detailed graphs of specific absorption rate versus microwave frequency have been developed for a series of man and animal models. These data are based on theoretic calculations and preliminary experimental verification below resonance, projections based on approximate models above resonance, and combined theoretic and experimental studies near the resonance region. The resonance region for many of the

#### MICROTRANSDUCER PACKAGING

An integrated circuit pH microtransducer has been packaged at the tip of 5 and 6 French 2-lumen catheters. This particular packaging configuration has proven to be so convenient that it will be used in future *in vitro* studies and is additionally suitable for planned animal studies. Recent long-term tests have indicated that these pH transducers respond well after 3 mo of continuous testing. This project is supported by a grant from the National Institute of General Medical Sciences.

*Utah Bioengineering Newsletter* 4(1): 1; 1976

#### ITEMS FROM THE COMMERCE BUSINESS DAILY

##### ☐ FURTHER RESEARCH ON THE EFFECT OF ELECTROMAGNETIC FIELDS ON THE CENTRAL NERVOUS SYSTEM OF MAMMALS.

The Office of Naval Research, Arlington, Virginia, has contracted with the Regents of the University of California, Los Angeles, California, for the above study. (December 8, 1976)

##### ☐ RELIABILITY GROWTH MICROWAVE STUDIES.

The Naval Electronic Systems Command, Washington, DC, will conduct negotiations with Tractor, Incorporated, Austin, Texas, for the above contract. (December 24, 1976)

##### ☐ EFFECTS OF MICROWAVE RADIATION ON THE NERVOUS SYSTEM.

The National Institutes of Health, Bethesda, Maryland, are negotiating with the University of Washington at Seattle for additional work under the above contract. (December 15, 1976)

## MEETINGS AND CONFERENCES

### THIRD INTERNATIONAL CONFERENCE ON STATIC ELECTRICITY

*Date:* April 18-20, 1977  
*Place:* Grenoble, France  
*Sponsor:* European Federation of Chemical Engineering; Society of Industrial Chemistry (Fr)  
*Requests for Information:* Society of Industrial Chemistry

### INTERNATIONAL RADIATION PROTECTION: ASSOCIATION IV INTERNATIONAL CONGRESS

*Date:* April 24-30, 1977  
*Place:* Paris, France: Paris Convention Center  
*Sponsor:* IRPA  
*Requests for Information:* Gilbert Bresson, BP 33, 92260-Fontenay-aux-Roses, France

### AMERICAN INDUSTRIAL HYGIENE CONFERENCE

*Date:* May 22-27, 1977  
*Place:* New Orleans, LA: Fairmount  
*Sponsor:* American Industrial Hygiene Assn.; American Conference of Governmental Industrial Hygiene  
*Requests for Information:* W. E. McCormick, AIHA

### FOURTH INTERNATIONAL CONFERENCE ON ELECTRICITY DISTRIBUTION (CIRED)

*Date:* May 23-27, 1977  
*Place:* London, United Kingdom: Royal Lancaster  
*Sponsor:* CIRED  
*Requests for Information:* Org. Comm., 4 CIRED, c/o IEE Conference Dept., Savoy Place, London, WC2R 0BL, UK

### MICROWAVE POWER SYMPOSIUM

*Date:* May 25-28, 1977  
*Place:* Minneapolis, Minnesota  
*Sponsor:* International Microwave Power Institute  
*Requests for Information:* Mr. O. P. Snyder, University of Minnesota, Saint Paul, MN

### INTERNATIONAL IEEE/AP SYMPOSIUM 7 USNC/URSI MEETING (RADIO SCIENCE/ANTENNAS AND PROPAGATION)

*Date:* June 20-24, 1977  
*Place:* Palo Alto, California  
*Sponsor:* Inst. of Electrical & Electronics Engineers (AP, Int.); Int. Union of Radio Science--US National Committee (USNC/URSI)  
*Requests for Information:* J. B. Damonte, 1716 Hillman Avenue, Belmont, CA 94002

### URSI SYMPOSIUM ON ELECTROMAGNETIC WAVE THEORY

*Date:* June 20-24, 1977  
*Place:* Palo Alto, CA: Stanford Univ.  
*Sponsor:* URSI (US National Committee)--International Union of Radio Science  
*Requests for Information:* Dr. F. M. Tesche, Science Applications, Inc., Box 277, Berkeley, CA 94701

### 1977 IEEE MTT INTERNATIONAL MICROWAVE SYMPOSIUM

*Date:* June 21-23, 1977  
*Place:* San Diego, California  
*Sponsor:* Institute of Electrical & Electronics Engineers (MTT)  
*Requests for Information:* D. Rubin, Code 2330, NELC, San Diego, CA 92152

### SECOND ELECTROMAGNETIC COMPATIBILITY SYMPOSIUM AND EXHIBIT

*Date:* June 28-30, 1977  
*Place:* Montreux, Switzerland  
*Sponsor:* Conv. of Natl. Electrical Engineering Assn. of W. Europe (EUREL); Int. Union of Radio Science (URSI); Inst. of Electrical and Electronics Engineers (EMC Gp) (Int.); Soc. of Auto Engineers (AE-4) (USA); et al.  
*Requests for Information:* T. Dvorak, ETH Zentrum (HF), 8092 Zurich, Switzerland

### INTERNATIONAL SYMPOSIUM ON MICROWAVE DIAGNOSTICS OF SEMICONDUCTORS

*Date:* July 13-15, 1977  
*Place:* Porvoo, Finland: Haikko Manor  
*Sponsor:* Technical Research Ctr. of Finland--VTT (Semiconductor Lab.); Helsinki Univ. of Technology (Electron. Physics Lab.) Finland  
*Requests for Information:* R. Paananen, VTT

### ELECTROMAGNETIC COMPATIBILITY SYMPOSIUM

*Date:* July 26-28, 1977  
*Place:* Seattle, WA: Washington Plaza  
*Sponsor:* Inst. of Electrical & Electronics Engineers (EMC)  
*Requests for Information:* B. L. Carlson, Jr., Boeing Co., Box 3029, Seattle, WA

### SEVENTH EUROPEAN MICROWAVE CONFERENCE

*Date:* September 5-8, 1977  
*Place:* Copenhagen, Denmark: Bella Center

**MEETINGS AND CONFERENCES**

*Sponsor:* Dansk Ingeniorgorening  
*Requests for Information:* Professor Preben  
Gudmandsen, Conf. Chairman, Electronics Inst.,  
348 Technical Univ. of Denmark, DK--2800 Lyngby,  
Denmark

**INTERNATIONAL SYMPOSIUM ON BIOLOGICAL  
EFFECTS OF ELECTROMAGNETIC WAVES**

*Date:* October 30-November 4, 1977  
*Place:* Airlie, Virginia  
*Sponsor:* International Union of Radio Science  
Commissions A and B  
*Requests for Information:* Professor Saul W.

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Radiation 1(3), April 1977*

Rosenthal, Chairman, Symposium Steering Committee  
Polytechnic Inst. of NY, Route 110, Farmingdale,  
NY 11735

**ENGINEERING IN MEDICINE AND BIOLOGY  
CONFERENCE**

*Date:* November 5-9, 1977  
*Place:* Los Angeles, California  
*Sponsor:* Alliance for Engineering in Medicine and  
Biology  
*Requests for Information:* Mrs. P. I. Horner,  
Asst. Dir. & Conf. Coordinator, Alliance for  
Engineering in Medicine and Biology, Suite 1350,  
5454 Wisconsin Ave., Chevy Chase, MD 20015

## CURRENT RESEARCH

0089 RADIOIMMUNOASSAY OF NEUROENDOCRINE CHANGES FOLLOWING MICROWAVE EXPOSURE. Vetter, R. J. (Purdue Univ., Sch. Pharmacy, Executive Building, Lafayette, IN 47907).

The feasibility of using radioimmunoassay to monitor changes in pituitary and thyroid hormone levels in the serum of animals exposed to various levels of nonionizing radiation will be determined. Rats will be exposed to 2450 MHz microwave radiation 8 hr/day for 21 consecutive days. Before exposure and at 7, 14, and 21 days of exposure and at 7 days following exposure, some rats will be sacrificed, and the levels of T3, T4, and thyroid-stimulating hormone in the serum will be determined by radioimmunoassay techniques. (6/76-5/77)

Supporting Agency: Purdue Res. Foundation.

0090 NONINVASIVE ESTIMATION OF TISSUE TEMPERATURE. Diller, K. R.; Eberhart, R. C.; Cogdell, J. R.; Thompson, K. (Univ. Texas, Sch. Engineering, 200 W. 21st St., Austin, TX 78712).

Microwave radiation emission from biologic tissue is detectable at depths up to 1 cm with conventional Dicke-switched superheterodyne radioastronomy radiometers. This allows for the potential detection of tumors, estimation of the severity of burns, and estimation of blood flow, undetectable by conventional infrared thermography. Microwave antennas and receivers, which most efficiently couple with and can be adapted to, biologic tissue will be designed and analyzed. Data on radiation absorption coefficients, their frequency and temperature dependence and tissue specificity, will be determined to assess the effectiveness of this technique. (7/75-6/76)

Supporting Agency: Univ. Texas.

0091 ELECTRICAL & ACOUSTIC PROPERTIES OF BIOLOGIC MATERIAL. Schwan, H. P.; Takashima, S.; Fischler, H.; Schwartz, G. (Univ. Pennsylvania, Sch. Engineering & Applied Science, 4001 Spruce St., Philadelphia, PA 19104).

Research will be conducted on the electrical and acoustic properties of biologic materials and on electrode polarization and forces induced by alternating electrical fields acting on biologic particles. Present and future emphasis will be on: (1) The behavior of electrodes used for impedance measurements and excitation purposes in physiology and cardiology (pacemaker), with particular emphasis on their nonlinear characteristics. (2) Electrical characteristics of macromolecules and water bound to their surface. (3) Electrical characteristics of biologic and artificial cells and membranes as related to their structure and function. (4) Acoustic properties of tissues and biologic macromolecules and the reasons why their specific absorption varies from one type to another. (5) Field induced force effects, particularly alternating field induced forces acting on biologic cells to determine

their hazards or potential for new biologic research techniques. (9/76-11/76)

Supporting Agency: HEW, PHS, NIH, Natl. Heart, Lung & Blood Inst.

0092 LABILE METABOLITES, TRANSMITTERS IN THE HEART CYCLE. Stavinocha, W. B.; Medina, M. A.; Modak, A. T.; Jones, D.; Deam, A. P. (Univ. Texas, Sch. Medicine, 7703 Floyd Curl Drive, San Antonio, TX 78284).

Electromagnetic radiation is being used to inactivate the enzymes at specific times during the beat cycle of the spontaneously beating turtle heart. Electrocardiogram and reflectometry is used to monitor events in the beat. After inactivation of the enzymes, the following compounds from the right and left auricles, ventricular apex, and ventricular base are assayed: acetylcholine, choline, cyclic adenosine monophosphate and guanosine monophosphate, the high energy phosphates, lactate, and pyruvate. (9/76-8/77)

Supporting Agency: HEW, PHS, NIH, Natl. Heart, Lung & Blood Inst.

0093 EFFECT OF PHYSICAL STIMULI ON INSECTS. Earp, U. F.; Perumpral, J. V. (Virginia Polytechnical Inst. & State Univ., Sch. Agriculture & Life Science, Burruss Hall, Blacksburg, VA 24061).

The objective of this project is to determine the response of certain insects of economic importance in Virginia to physical stimuli, especially electromagnetic field energy, and to determine the feasibility of using such stimuli as an attractant or repellent of insects or as a population suppressant. Insect behavior will be studied in magnetic and electrostatic fields in the zero frequency range. Experiments will be conducted to determine the effect of electromagnetic fields in flight chambers for orientation behavior, in homogeneous fields for egg-laying and hatchability, and in CO<sub>2</sub> production monitoring for insect activity. Tests to determine the effect of electrostatic fields on oviposition among cabbage loopers were completed. Field gradients ranging from 100 V/cm to 5000 V/cm were considered. Results show that in higher gradient fields egg production is comparatively lower than normal. These results are useful to evaluate the potential use of electrostatic fields for the control of insects. A manuscript entitled *Low-Intensity Magnetic Field Studies on Cabbage Looper* was completed. The final report on the study is being prepared. (10/76-9/77)

Supporting Agency: Virginia State Government.

0094 HATCHABILITY OF CHICKEN AND TURKEY EGGS. Krueger, W. F. (Texas A & M Univ. System, Agricultural Experiment Station, College Station, TX 77843).

## CURRENT RESEARCH

*Biological Effects Nonionizing Electromagnetic Radiation 1(3), April 1977*

This study will investigate and evaluate incubational and pre-incubational factors influencing hatchability of chicken and turkey eggs under southern climatic conditions. The causes of egg spoilage during incubation will be determined, and methods of preventing this condition will be established. Incubational and pre-incubational factors necessary for optimum embryonic development will be correlated with seasons. The interrelationships between hatchability and other genetic characters of economic importance will be investigated under varying incubational and pre-incubational conditions. Pedigree hatching eggs will be characterized after treatment by various chemical and weight measurements of the shell, albumen, and yolk of eggs 1 wk each mo. Similar eggs from the same pedigreed hens will be incubated usually under three incubation conditions to determine treatment effects. Studies are in progress to determine methods of efficiently preventing spoilage of hatching eggs and of sanitizing hatching eggs prior to and during incubation. Genetic differences in the various egg characteristics must eventually be related to other physiologic characteristics of the bird to avoid genetic antagonisms. Records are being kept on a pedigree basis to study these potential antagonisms. Experiments with laying hens and males exposed to three types of electromagnetic fields for a 20 wk period resulted in significant differences in rate of egg production. There were no significant differences produced in fertility, hatchability, chick quality, or sex ratio. Continuous exposure to microwaves at low power densities and low level magnetic and electric fields did not appear to influence reproductive ability of chickens. (10/76-9/77)

Supporting Agency: Texas State Government.

0095 QUANTIFICATION & MEASUREMENT OF INTERNAL ELECTROMAGNETIC FIELDS INDUCED IN FINITE BIOLOGICAL BODIES BY NONUNIFORM ELECTROMAGNETIC FIELDS. Chen, K. (Michigan State Univ., Sch. Engineering, Engineering Building, East Lansing, MI 48824).

See Current Research 0073. (10/76-9/77)

Supporting Agency: U.S. Dep. Def., Army.

0096 BIOPSYCHOLOGICAL STUDIES OF MICROWAVE IRRADIATION. Justesen, D. R.; Sheridan, C. L.; Garrison, R. G.; Levinson, D. M. (Univ. Kansas, Sch. Medicine, 39th & Rainbow Blvd., Kansas City, KN 66101).

Dose-determinant exposures of pregnant mice and rats to 2450 MHz and 915 MHz microwaves will be performed in studies of lethal-dosing, teratology, longevity, and maze-learning. Related studies will: (1) evaluate the role of endogenous (psychogenic) heating in mammals as induced by handling and restraint in lethality of dosing; (2) examine growth and ultrastructure of a thermophilic organism that exhibits retarded growth and hyperplasia of the plasma mem-

brane under microwave radiation; (3) record the ethogram of an avian species previously incubated in a microwave field; (4) determine the utility of evoked thermal responses as indicators of perception of microwave energy; and (5) obtain evidence of the use of hypothermal agents in mammals to determine the biosimeter of absorbed electromagnetic energy. The multimode cavity will be used for exposing organisms to microwaves and the effects of continuous wave versus pulsed radiations of the same average density will be compared. (9/76-8/77)

Supporting Agency: HEW, PHS, FDA.

0097 ACCELERATION OF FRACTURE HEALING BY ELECTRICAL FIELDS. Brighton, C. T.; Friedenberg, Z. B.; Black, J.; Korostoff, E.; Heppenstall, R. B. (Univ. Pennsylvania, Sch. Medicine, 36th & Hamilton Walk, Philadelphia, PA 19104).

This research will continue the investigation of the effects of an applied electrical current and/or field on the acceleration of fracture healing in laboratory animals. The research will determine the comparative effectiveness of direct constant and pulsed current, alternating current, electrostatic fields, and magnetically induced electrical fields in producing osteogenesis and in accelerating fracture healing in laboratory animals. In addition, the site and mechanism of action of electrical stimulation on medullary canal cells and on fracture callus cells will be determined. The methodology will include point-counting analysis of histologic sections for new bone formation produced in an intact medullary canal around a cathode in response to various parameters of current, voltage, electrostatic, and electromagnetic fields; mechanical testing for maximum resistance to bending of healing fractures in laboratory animals; point-counting analysis of electron micrographs of fracture callus cells to quantitate changes in cytoplasmic components; electron microscopy combined with histochemical analysis of fracture callus cells to detect changes in cell membrane surface charges; and determination of changes in tissue  $pO_2$ ,  $O_2$ , and  $pCO_2$  consumption using a tissue tonometer system. (9/76-8/77)

Supporting Agency: HEW, PHS, NIH, NIAMD.

0098 NAVY ENVIRONMENT: QUANTITATION OF MICROWAVE RADIATION EFFECTS ON THE HEAD AND EYES OF RABBITS, PRIMATES AND MAN. Kramar, P. O.; Emery, A. (Univ. Washington, Sch. Medicine, 500 17th Ave., Seattle, WA 98122).

Exposure to microwave radiation can cause the production of opacity and damage in the eye. The exact conditions under which these effects occur are yet to be established; consequently, there is a great deal of controversy concerning the safe level of human exposure to microwave radiation. The increased use of high power microwave equipment by the Navy and other armed services, as well as the

general population, demands well-planned and expertly executed theoretic and experimental investigations. Rabbits will be exposed to 300 mW/cm<sup>2</sup> incident power (2450 MHz) level for subthreshold time periods but with the interval between exposures varying by 1 to 5 days. These tests should help to determine: (1) the period of time needed between exposures that will "protect" the lens from permanent damage, and (2) whether repeated subthreshold exposures alter the temperature regulating mechanisms of the eye. Rabbits will also be exposed to lower power levels, using a slot irradiator, to determine the lowest threshold level for the formation of cataracts. The slot threshold for the monkey will also be determined. An investigation of the effects of long-term, low level chronic irradiation on rabbits has been initiated and will be continued for at least another year. Electron-microscopic studies and fluorescein angiography will be used to help determine the mechanism of cataract formation. (10/76-9/77)

Supporting Agency:U.S. Dep. Def., Navy.

0099 THE EFFECTS OF LOW POWER DENSITY ELECTROMAGNETIC ENERGY ON BIOLOGICAL SYSTEMS. Flanigan, W. F.; Ridgway, S. H. (U.S. Navy, Biosystems Research Dept., San Diego, CA 92132).

The electrophysiology (i.e., brain wave activity and heart rate) and behavior of reptiles exposed to low power density ( $\leq 10$  mW/cm<sup>2</sup>) electromagnetic radiation will be studied at 960 and 2450 MHz. Turtles, land tortoises, the North American box turtle, the North American painted turtle, and the Southern California desert tortoise will be used. Electroencephalograms and electrocardiograms will be recorded from semichronically implanted animals. Averaged cortical evoked potentials will also be recorded using a computer of averaged transients. Animals will be unanesthetized but fully restrained during exposure and recordings. Baseline recordings prior to field exposure will be compared with those obtained when an animal is exposed to electromagnetic radiation. The cumulative effects of recurring field exposure will also be investigated. (10/76-9/77)

Supporting Agency:U.S. Dep. Def., Navy.

0100 RADIOFREQUENCY RADIATION EFFECTS ON BIOCHEMICAL SYSTEMS IN THE CENTRAL NERVOUS SYSTEM. Merritt, J. H.; Frazer, J. W. (U.S. Air Force, Sch. Aerospace Medicine, Brooks Air Force Base, San Antonio, TX 78235).

The Department of Defense Triservice Electromagnetic Radiation (EMR) Bioeffects Research Program describes the central nervous system (CNS) as the "singularly most important area where there is evidence that EMR interacts with biological systems." The objective of this effort is to quantitate the radiofrequency (RF) EMR effects on biochemical events subserving nerve transmission in the CNS. The informa-

tion obtained will be applied to establish more appropriate safety standards for personnel working in close proximity to Air Force RF emitters. The effects of RF radiation on the CNS, specifically on a specialized function of the neuron, namely synaptic transmission, will be studied: brain cells are connected, directly or indirectly, by chemical switching systems (synaptic transmission). This effort will attempt to quantify changes produced by RF energy in these chemical systems, determine thresholds for frequency and power density, and interpret these changes in terms of the expected effect on man in Air Force operational environments. (10/76-9/77)

Supporting Agency:U.S. Dep. Def., Air Force.

0101 RADIOFREQUENCY RADIATION INTERFERENCE (RFI) OF MEDICAL PROSTHETIC DEVICES. Mitchell, J. C.; Hardy, K. A. (U.S. Air Force, Sch. Aerospace Medicine, Brooks Air Force Base, San Antonio, TX 78235).

A biomedical data base on the interaction of Air Force radiofrequency (RF) radiation emitters and medical prosthetic devices will be established. The data will be applied to operational situations in accordance with Air Force regulation (AFR) 161-42. The effort will include a state-of-the-art technology watch on cardiac pacemaker interference. Manufacturers' progress in developing pacemakers to operate properly in pulsed RF fields of 200 root-mean-square V/m will be assessed. New state-of-the-art technology pacemakers will be accepted on loan from manufacturers and evaluated under a variety of RF emission sources in the USAFSAM laboratory. Sources will include radiofrequencies between 50-500 MHz. Field tests will also be conducted using a high frequency band transmission system at Ava, NY. Additional field tests will be conducted in support of specific operational problems as provided by AFR 161-42. (10/76-9/77)

Supporting Agency:U.S. Dep. Def., Air Force.

0102 VISUAL SYSTEM DISEASES IN AIRCREWMEN. Tredici, T. J.; Burman, M. L. (U.S. Air Force, Sch. Aerospace Medicine, Brooks Air Force Base, San Antonio, TX 78235).

The incidence and significance of ophthalmologic disorders in flying personnel will be determined from the standpoint of retention without compromising flying safety. The means to prevent or correct such disorders, and techniques for early diagnosis or prediction of development of such disorders will be developed. Flying personnel with ophthalmologic problems will receive a comprehensive aeromedical evaluation and a battery of function testing, including manifest and cycloplegic refractions, motility tests, tonometry, tonography, funduscopy and fundus photography. The response to aerospace environmental factors (i.e., acceleration, altitude and electromagnetic radiation) will be studied in special

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cases. Longitudinal basic studies will assess the significance of disease in relationship to flying operations and the validity of current aeromedical standards. Fluorescein fundus photography, electroretinography, electrooculography, static perimetry, and biomicroscopy will be utilized in studying the effect of disease and stress on aircrewmen. (10/76-9/77)

Supporting Agency:U.S. Dep. Def., Air Force.

0103 CLINICAL ASPECTS OF MICROWAVE EXPOSURE. Michaelson, S. M. (Univ. Rochester, Sch. Medicine & Dentistry, 401 Elmwood Ave., Rochester, NY 14642).

Evaluation of alterations in the functional status of the neuroendocrine system after exposure to microwaves and elucidation of threshold levels, cumulative effects, interaction with other stresses and environmental factor is the objective of this study. Mature rats will be exposed to microwave irradiation in three different regimens: 100 mW/cm<sup>2</sup>, 10 mW/cm<sup>2</sup>, and 1 mW/cm<sup>2</sup> for 8 wk. Periodically throughout the exposure, body weight and temperature will be taken, and blood drawn. Gross behavioral observations will also be made. Thyroid function will be evaluated using T3 and T4 resin sponge absorption studies. Pituitary function will be determined by a bioassay of thyroid-stimulating hormone. (10/76-9/77)

Supporting Agency:U.S. Dep. Def., Navy.

0104 NAVY ENVIRONMENT: INVESTIGATION OF THE BIOLOGICAL EFFECTS OF PULSED ELECTROMAGNETIC FIELDS GENERATED BY NAVAL OPERATIONS. Cleary, S. F. (Virginia Commonwealth Univ., Sch. Medicine, 1200 East Broad St., Richmond, VA 23298).

See Current Research 0013. (10/76-9/77)

Supporting Agency:U.S. Dep. Def., Navy.

0105 NAVY ENVIRONMENT: EFFECTS OF BIOLOGICAL SYSTEMS DUE TO EXPOSURE TO MICROWAVES. Durney, C. H.; Lords, J. L. (Univ. Utah, Sch. Engineering, 1400 East 2nd St., Salt Lake City, UT 84112).

See Current Research 0011. (10/76-9/77)

Supporting Agency:U.S. Dep. Def., Navy.

0106 NAVY ENVIRONMENT: EFFECTS OF MICROWAVES ON MATURATION IN THE RAT. Michaelson, S. (Univ. Rochester, Sch. Medicine & Dentistry, 401 Elmwood Ave., Rochester, NY 14642).

See Current Research 0050. (10/76-9/77)

Supporting Agency:U.S. Dep. Def., Navy.

0107 MEASUREMENT OF POWER DISTRIBUTION AT RESONANT AND NONRESONANT FREQUENCIES IN EXPERIMENTAL ANIMALS AND MODELS. Guy, A. W.; Lovely, R. H. (Univ. Washington, Sch. Medicine, 500 17th Ave., Seattle, WA 98122).

See Current Research 0046. (10/76-9/77)

Supporting Agency:U.S. Dep. Def., Air Force

0108 NAVY ENVIRONMENT: BIOMEDICAL EFFECTS OF RADIO FREQUENCY RADIATION. Lin, J. C.; Kraus, G. E. (Wayne State Univ., Sch. Engineering, 5950 Cass Ave., Detroit, MI 48202).

See Current Research 0059. (10/76-9/77)

Supporting Agency:U.S. Dep. Def., Navy.

0109 MICROWAVE IRRADIATION OF BRAIN THROUGH CRANIOPLASTY. Sutton, C. H. (Univ. Miami, Sch. Medicine, 1400 N.W. 10th Ave., Miami, FL 33124).

No descriptive information is available. (1/77-12/77)

Supporting Agency:American Cancer Soc., Inc.

0110 COMPARISON OF THEORETICAL AND EXPERIMENTAL ABSORPTION OF RADIOFREQUENCY POWER. Johnson, C. C.; Durney, C. (Univ. Utah, Sch. Engineering, 1400 East 2nd St., Salt Lake City, UT 84112).

Methodology for quantitating electromagnetic radiation (EMR) energy distribution and measurement will be developed. Methods and data are critically needed to extrapolate (via appropriate scaling factors) animal data to man to establish more realistic personnel safety exposure guidelines for Air Force operations. The specific objectives of this study are (1) to define adequate models, (2) to extend theoretic radiofrequency (RF) power absorption data to assess consequences of human exposure to 10 KHz to 1.5 GHz RF radiation fields, and (3) to develop methods, accounting for size and orientation effects, to extrapolate animal exposures to equivalent human exposures. Twenty phantoms will be constructed to simulate 3.5 kg monkeys. Absorbed power will be calculated utilizing this monkey model for exposures in free space, near field, and on a ground plane. Experiments will be conducted to measure power absorbed in the phantom and in actual monkeys for six exposure orientations. The best model for man, monkey, rat and mouse will be developed and calculations will be performed to determine power density to which these animals should be exposed to produce the same average absorbed power as man when exposed to 10 mW/cm<sup>2</sup> at the same frequency. The exposure frequency for animals subjected to the same power density as man to accomplish equivalent average power absorption will also be calculated. These data will be used to compile a handbook (Researcher's Guide) for use in selecting appropriate exposure parameters (frequency and power

density) for animal studies to simulate bioeffects in man. Power absorption calculations for man and animals will be extended to 1.5 GHz using wave solution, numeric techniques, or other applicable methods. (10/76-9/77)

Supporting Agency:U.S. Dep. Def., Air Force.

- 0111 BIOLOGICAL EFFECTS OF AIR FORCE TRANSMITTER NEAR FIELDS. Stavinoha, W. B.; Medina, M. A. (Univ. Texas, Sch. Medicine, 7703 Floyd Curl Drive, San Antonio, TX 78284).

The independent and synergistic effects of high frequency band (3-30 MHz) magnetic and electric field vectors on a variety of biologic systems will be investigated using the USAFSAM "near-field" radiation simulator. This information is required to establish personnel exposure criteria in close proximity to Air Force high power radiofrequency radiation emitters operating in the frequency range of approximately 3-500 MHz. Various mammalian systems will be exposed in the "near field" simulator and studied to detect any possible alterations in growth and reproduction, central nervous system effects (neurotransmitter turnover, brain nucleotide levels, brain cyclic AMP assay), endocrine status (corticosteroid assays depending on experimental animal, water balance, vanillylmandelic acid, norepinephrine and epinephrine analysis), hematology (primates), and liver and renal function. In selected animals specific examination of the heart will be undertaken. (10/76-9/77)

Supporting Agency:U.S. Dep. Def., Air Force.

- 0112 EFFECTS OF MICROWAVE RADIATION ON THE NERVOUS SYSTEM. Lovely, R. H. (Univ. Washington, Sch. Medicine, 500 17th Ave., Seattle, WA 98122).

The effects of long-term, low intensity microwave exposure on the nervous system, particularly the brain, will be investigated. The effects of microwaves on the brain will be measured and correlated with behavior and biologic functions. (6/76-6/77)

Supporting Agency:HEW, PHS, NIH, Natl. Inst. Environmental Health Science.

- 0113 BEHAVIORAL EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION ON STORED-PRODUCT INSECTS. Bruce, W. A. (U.S. Dept. Agriculture, Stored Products Insects Research & Development Lab., 3401 Edwin Ave., Savannah, GA 31405).

The electromagnetic frequencies (EF) capable of controlling and/or altering insect behavior will be determined. Working models, based on insect physiology, morphology, and behavior by which economic

nonchemical control might be accomplished will be provided. Insects will be exposed to various frequencies and intensities to determine response, thresholds, and probable locations of sensory receptors. Precise receptor location will be accomplished electrophysiologically. Because of the increased power and wavelength penetrability of laser-produced infrared (IR) radiation, IR spectrum studies will utilize frequencies produced by gas lasers; the feasibility of using laser technology and techniques for behavioral work involving insect detection of and attraction/repulsion to these frequencies will be determined. The principle of differential absorption of laser-produced frequencies between commodity and insect will be utilized for possible detection and control of the infestation within the commodity. Electromagnetic radiation has been used to alter the behavior of several species of stored-product insects. UV radiation has been shown to have an extremely damaging effect on *Plodia interpunctella*, *Tyrophagus putrescentiae*, and *Pyemotes ventricosus*; although, each is able to repair the UV damage (photoreactivation) through either a light or dark mechanism. UV radiation has also been used to destroy the biologic activity of the synthetic sex pheromone of *P. interpunctella* and thereby provide a possible new nonchemical method of insect control. IR radiation emitted by a CO<sub>2</sub> gas laser has been used to elicit responses from two species of stored-product insects. The response was observed and quantified by two newly developed techniques. A system utilizing IR CO<sub>2</sub> analysis was developed to detect hidden insect infestations. The method is rapid, nondestructive, and applicable to a wide variety of materials, either packaged or bulk, and can be employed at any point in the marketing channel. (10/76-9/77)

Supporting Agency:U.S. Dept. Agriculture, Agricultural Res. Service, Georgia-South Carolina Area.

- 0114 IMPACT OF RF BIOEFFECTS ON AF OPERATIONS. Mitchell, J. C.; Hardy, K. A. (U.S. Air Force, Sch. Aerospace Medicine, Brooks Air Force Base, San Antonio, TX 78235).

A radiofrequency radiation (RFR) bioeffects technology data base will be maintained to support environmental impact positions and to establish operational RFR safety criteria for current and future Air Force systems. Specific biologic consequences of human exposure to unique pulsed radiofrequency fields from phased array emitters will be evaluated and compared with the findings of pulsed versus continuous wave radar exposure experiments. Radiofrequency radiation effects data will be compiled, analyzed, and applied to establish systems specific exposure criteria in accordance with Air Force mission requirements and operational situations. Additional research data will be obtained through a multi-agency contract with the Franklin Institute. (10/76-9/77)

Supporting Agency:U.S. Dep. Def., Air Force.

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- 0115 BIOLOGICAL EFFECTS OF AF RF TRANSMITTER  
FIELDS. Frazer, J. W.; Merritt, J. H.  
(U.S. Air Force, Sch. Aerospace Medicine, Brooks  
Air Force Base, San Antonio, TX 78235).

The setting of safety standards for Air Force personnel exposed to electromagnetic radiation (EMR) must rest on a foundation of known bioeffects. This effort will investigate radiofrequency (RF) field effects on biophysical model systems. The information gathered will allow the adjustment of exposure criteria for Air Force personnel working in unique RF radiation environments. Field modulation effects, including pulsed fields, on a variety of central nervous system (CNS) ionic and chemical distributions will be examined. The effects of EMR fields on solvent transport processes in tissue and polarization processes in macromolecules will also be investigated. Alterations in the trace metal content in various areas of the rat CNS will be related with frequency, power density, and thermal stress, and these findings will be extrapolated to an expected effect on Air Force personnel operating in EMR environments. (10/76-9/77)

Supporting Agency: U.S. Dep. Def., Air Force.

- 0116 EFFECTS OF MICROWAVE RADIATION ON THE NERVOUS SYSTEM. Gandhi, O. P. (Univ. Utah, Sch. Engineering, 1400 East 2nd St., Salt Lake City, UT 84112).

The effects of long term, low intensity microwave exposure on the physiologic function of the nervous system, particularly the brain of rodents, will be investigated. Biochemical analyses of the cholinesterase activity of the blood, the sulfhydryl groups in the blood, and ketosteroid in the urine will be performed, and the data will be correlated with nervous system and behavioral measurements. (6/76-6/77)

Supporting Agency: HEW, PHS, NIH, Natl. Inst. Environmental Health Science.

- 0117 CELLULAR EFFECT OF MICROWAVE RADIATION. Livingston, G. (Univ. Utah, Dept. Bio-engineering, Salt Lake City, UT 84112).

The biologic effects of 2450 MHz microwave radiation on cultured Chinese Hamster Ovary (CHO) cells are being investigated. One aspect of the study is the effect of such radiation on the reproductive integrity of the cells following treatment. Measurements of cell survival following hyperthermic exposure to microwave compared with conventional heating

in a water bath showed no significant differences in cell survival. Also being studied is the effect of microwave treatment on the frequency of sister chromatid exchange (SCE) in the chromosome complement of CHO cells. SCE frequency has been found to be highly sensitive to various physical and chemical carcinogens. Furthermore, it has been found that conventional hyperthermia (44°C) drives up the frequency of this event significantly. Work is underway to determine whether microwave heating has a comparable effect on SCE production and whether heat combined with x-ray exposure leads to an additive or possibly a synergistic effect on the formation of sister chromatid exchanges.

Supporting Agency: Not Specified

- 0118 MILLIMETER WAVE SPECTRA OF LIVING TISSUE. Gandhi, O.; Johnson, C.; Partlow, L.; Hill, D.; Stensaas, L.; Millhouse, G. (Univ. Utah, Sch. Engineering, 1400 East 2nd St., Salt Lake City, UT 84112).

To determine the microwave spectra over the 8-90 GHz band of normal and malignant cells, the absorption spectra of cells bearing temperature-sensitive viruses and cells with isolated spontaneous transformants and drug-induced transformants will be evaluated. Light and electron microscopy experiments will be performed to study the effects of microwave irradiation on the morphology of several cloned lines and primary cell cultures.

Supporting Agency: NIH

- 0119 BIOLOGICAL TEMPERATURE SENSOR USING OPTICAL ETALONS. Christensen, D. (Univ. Utah, Salt Lake City, UT 84112).

A fiberoptic temperature probe using a small solid optical cavity (etalon) as the sensor will be developed. Temperature will be determined by measuring the temperature-dependent wavelength shifts in the optical reflectivity nulls from the sensor. Such a probe, being entirely nonmetallic and non-perturbing, would find applications in microwave and radiofrequency biohazard studies, microwave cooking and thawing experiments, and microwave hyperthermia studies.

Supporting Agency: NIH

## CURRENT LITERATURE

### 4800 COMPARISON OF THEORETICAL AND EXPERIMENTAL ABSORPTION OF RADIOFREQUENCY POWER. (Eng.)

Allen, S. J.; Durney, C. H.; Johnson, C. C.; Mas-soudi, H. (Dept. Bioengineering, Univ. Utah, Salt Lake City, UT 84112). 16 pp. 1975. [available through National Technical Information Services, Washington, D.C., Document No. AD A022890].

Power absorption calculations using prolate spheroid models were performed for radiofrequency exposures between 10 and 50 MHz, and these data were compared with experimental data obtained from saline-filled prolate spheroid monkey and human phantoms as well as from live monkeys (rhesus primates). The agreement, generally, between the calculated and measured values for the phantoms was good, with the best agreement occurring at the higher frequencies. The perturbation theory appeared to be valid for describing the power absorbed by prolate spheroid phantoms. A total of 20 live monkeys, however, absorbed significantly more power than the phantoms, and data taken at a frequency of 40 MHz revealed significant differences in absorbed power at a given polarization when the monkeys were rotated about their long axis. This indicated that a spheroid, which is circular in cross section, is not an adequate model for the monkey. Ellipsoid models better approximated power absorption for both monkeys and humans. (2 refs.)

### 4801 ELECTROPHYSIOLOGICAL EFFECTS OF ELECTRO-MAGNETIC FIELDS ON ANIMALS. (Eng.) Guy, A. W.; Lin, J. C.; Chou, C. K. In: *Fundamental and Applied Aspects of Nonionizing Radiation*. Michael-son, S. M.; Miller, M. W.; Magin, R.; Carstensen, E. L., eds. (New York: Plenum Press): pp. 167-211; 1974.

*In vivo* and *in vitro* studies were performed on nervous tissues of cats exposed to microwave radiation to determine thresholds of electrophysiologic phenomena observed in absorbed electromagnetic power levels and possible temperature increases at sites of interaction. The microwave frequencies extended from ultra-high frequency to X band, and the exposure facilities included near zone reflectors, horns and apertures, and waveguide irradiation chambers. It was shown that the conduction and transmission latencies and amplitudes of evoked potentials in both the central nervous system of anesthetized cats, isolated nerves of cats, and ganglia of rabbits were affected by continuous wave (CW) micro-waves in a manner very similar to that of localized conduction heat. Temperature rises were always associated with observable changes of the measured characteristics in the nervous tissues exposed to CW irradiation. The threshold of occurrence of latency changes was between 2.5-5.0 W/kg of absorbed power density in the affected tissues, which is about one-quarter to one-half of the normal metabolic rate of brain tissue. This absorbed power corresponds to 5-10 mW/cm<sup>2</sup> and 10-25 mW/cm<sup>2</sup> incident upon a cat head and a human head, respectively. Pulsed microwaves of high peak intensity and low average power induce a hearing phenomenon in man. Electrophysiologic studies on cats indicated that

pulsed microwaves interact with mammalian auditory systems in a manner similar to that of conventional acoustic perception. The authors suggest that a possible mechanism of microwave interaction is the acoustic energy release from rapid thermal expansion due to power absorption in the gross structure of the head. (44 refs.)

### 4802 USE OF MICROWAVE AND LOWER FREQUENCY RF ENERGY FOR IMPROVING ALFALFA SEED GERMINATION. (Eng.) Nelson, S. O. (Univ. of Nebraska, Lincoln, NB 68583). *J. Microwave Power* 11(3): 271-277; 1976.

The use of microwave and radiofrequency energy for increasing the germination of alfalfa seed (*Medicago sativa* L.) by lowering the hard-seed content is reported. Exposure of alfalfa seed to frequencies of 5, 10, 39, and 2450 MHz effectively reduced the hard-seed percentages and provided increased seedling germination; all of these frequencies were equally effective when the resulting seed temperatures were comparable. Germination responses to different field intensities were also similar when the final temperatures were similar. Moisture in the seeds was an important factor, with treatments generally more effective at lower seed moisture contents. Optimum germination response to microwave and radio-frequency radiation depended mainly on the elevation of the seed temperature to the proper level. The optimum temperature for increasing seed germination was about 75°C for seed lots of normal moisture content (about 6-7%). (19 refs.)

### 4803 BRAIN TEMPERATURE AND ENZYME HISTOCHEMISTRY AFTER HIGH INTENSITY MICROWAVE IRRADIATION. (Eng.) Butcher, L. L. (Dept. Psychology, Univ. California, Los Angeles, CA 90024); Butcher, S. H. *Life Sci.* 19(7): 1079-1088; 1976.

Cerebral temperature measurements and histochemical analyses were performed on the brains of male and female Sprague-Dawley rats following exposure to high intensity microwave irradiation. The brains were subjected to low intensities of microwave radiation of 2.5 kW x 1.0 sec, 5.0 kW x 0.5 sec, or less, and higher intensities of 2.5 kW x 2.0 sec, 5.0 kW x 1.0 sec, or more. It was found that brain temperature increased with increasing intensities of irradiation. Histochemically assessed telencephalic and mesencephalic acetylcholinesterase (AChE) was inactivated for a considerable distance pericentrally by a microwave power level of 5.0 kW applied for 0.5 sec. With these parameters, core brain temperature was 56°C, and neuronal somata in the red nucleus and other neural regions displayed pyknotic nuclei or compacted nucleoli, an inflated appearance, and decreased Nissl staining. AChE was completely inactivated by a 1-sec application of 5.0 kW microwave power. At the same time brain temperature was 78°C, and, as after lower intensities of microwave irradiation, neuronal somata were hypochromic and in-

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flated. NADH-diaphorase was found to be less thermolabile than AChE. Because it more rapidly inactivates thermolabile brain enzymes, compared with freezing by immersion and chemical fixation protocols, the use of microwave irradiation of neural tissue is recommended for neurochemical studies. (25 refs.)

### 4804 NERVOUS SYSTEM CHANGES IN WORKERS OF RADIO-TELEVISION STATIONS EXPOSED TO MICROWAVES.

(Pol.) Bielski, J. (Wielkopolski Zespół Specjalistyczny Medycyny Przemysłowej, Instytut Chorób Wewnętrznych AM, 60-852 Poznań, ul. Poznańska 55a, Poland); Pianowska, J.; Sawinska, A.; Gruszka, W. *Pol. Tyg. Lek.* 31(32): 1369-1372; 1976.

A group of 115 people, mean age 40 yr, with a mean length of 10 yr of employment in television and radio, was evaluated for the effect of microwaves on their central nervous system. Among them, 88 worked within the range of tele-radio-communication equipment with a microwave frequency of 3,000-7,000 MHz and a power density below 0.1 W/m<sup>2</sup>. Another 27 workers were not directly exposed to the emission of microwaves, and 39 of equal age and tenure, who worked outside of microwave range, served as controls. A complete psychophysical examination established that the complaints of 88.7% of the exposed people were the result of autonomic nervous system dysfunction. However, the same syndromes were also found in 70% of the controls--probably due to the stress-inducing nature of their work. Among the exposed individuals, slight but significant cardiovascular alterations and increased pathologic lenticular eye changes were observed compared to controls. The microwave exposed group showed a higher resistance to stress and reduced sociability. Electroencephalograms in both exposed groups revealed a higher number of flat low-voltage tracings in younger men than in controls. The autonomic nervous system and electroencephalogram changes observed were minor. (9 refs.)

### 4805 ENERGY ABSORPTION PATTERNS IN CIRCULAR TRIPLE-LAYERED TISSUE CYLINDERS EXPOSED TO PLANE WAVE SOURCES. (Eng.) Ho, H. S. (U.S. Dept. Health, Education, Welfare, Public Health Service, Food and Drug Admin., Bureau Radiological Health, Div. Biological Effects, 5600 Fishers Lane, Rockville, MD 20852). *Health Phys.* 31(2): 97-108; 1976.

The energy absorption patterns in arm and thigh triple-layered phantom tissue circular cylinders were calculated for plane wave sources of 433, 750, 918, and 2450 MHz. The three layers simulated fat, muscle, and bone. At all frequencies for incident E<sub>z</sub> polarized (TM) plane waves, the absorption pattern in the thigh model was less intense in the fat region than in the muscle region; the bone region had practically no absorption. At 2450 MHz, the absorption in the muscle attenuated almost exponentially from the fat-muscle interface. The absorp-

tion patterns in the thigh model resulting from H<sub>z</sub> polarized (TE) plane waves were similar to those of the E<sub>z</sub> polarized (TM) case. However, at 433 MHz, there was high intensity in the muscle region at the muscle-bone interface. In the arm model, at all frequencies of incident E<sub>z</sub> polarized (TM) plane waves the absorption in the bone region was negligible, while the absorption in the fat region was smaller than that of the muscle region. In the arm model, the H<sub>z</sub> polarized (TE) plane wave source resulted in patterns similar to those of the E<sub>z</sub> polarized (TM) case. However, the absorption in the muscle region was more intense at the muscle-bone interface than at the fat-muscle interface. It is concluded that since there is a large variation of energy absorption characteristics in tissues, these characteristics should be considered in the design and interpretation of experimental results in relation to health protection. Dosimetry in biologic effects experiments should be quantified in terms of total absorbed energy and the distribution of the absorbed energy in the biologic body. (7 refs.)

### 4806 HYGIENIC ASSESSMENT OF AN ELECTROMAGNETIC FIELD CREATED BY HIGH-VOLTAGE LINES OF ELECTRO-TRANSMISSION. (Rus.) Dumansky, Y. D. (A. N. Marzhev Kiev Scientific Res. Inst. of General and Communal Hygiene, Kiev, USSR); Popovich, V. M.; Rokhvati, E. V. *Gig. Sanit.* (8): 19-23; 1976.

The intensity of electromagnetic fields around high-voltage, 50 Hz, power transmission lines was measured, and the effect of such fields (100-5,000 V/m) on various physiologic parameters was studied in male albino rats in a 4-mo experiment. Power transmission lines with 330-750 kV generated electromagnetic fields with intensities of 1,500-7,500 V/m at 10 m distance, and of 100-350 V/m at 50 m distance. Excitation, unusual motor activity alternating with inhibition, and hyperemia of the mucosa of the nose and eye were observed in rats exposed to 5,000 V/m. In the groups exposed to 1,000-5,000 V/m the following effects were observed: reduction of the blood cholinesterase activity by 34.3-37.8%, reduction of the sulfhydryl group level by 12.4-16.6%, significant increase in the urinary 17-ketosteroid level, and reduction of the fixation and elimination of radioactive iodine in the thyroid gland. In addition, significant hyperglycemia, significant increase in the residual nitrogen and urea levels in the blood, reduction of the oxidative phosphorylation in the brain and liver cell mitochondria, and increased serum lactate and succinate dehydrogenase activities were observed. Dystrophy of tissues and vascular changes were found at the end of the experiment in the brain, myocardium, liver, kidneys, adrenals, and thyroid gland. These changes were proportional to the field intensity to which the animals had been exposed. The results suggest that electromagnetic field around high voltage power transmission lines pose a potential health hazard to adjacent populated areas. (5 refs.)

4807 THE EFFECT OF A STATIC ELECTRIC FIELD ON THE BODY OF MAN AND ANIMALS. (Rus.)

Skorobogatova, A. M. (Leningrad Inst. Hygiene and Medicine, Leningrad, USSR); Tarasova, G. M.; Soloviev, A. V.; Plotnikov, V. G.; Plotnikova, L. B.; Yakovleva, M. N. *Gig. Sanit.* (6): 20-24; 1976.

The effect of static electric fields on textile mill workers was studied, and related experiments were carried out on rabbits. Potentials of 2,800-25,000 V/cm were measured in a textile mill at air humidities of 35-55%. The static field potential decreased with increasing humidity. The incidences of hypertension and vegetative dysfunction were 7.6 and 35.8%, respectively, versus 1.4% and 5.7% in the control group. Static electric field reduced the skin resistance and increased the perspiration. In rabbits exposed to static electric field (1,000 V/cm) for 2 hr, dilatation of the cutaneous vessels on the back and ears, increased skin temperature, pronounced bradycardia (25% reduction of the heart rate), and absence of reflex reaction of the heart to the skin irritation were observed. The findings indicate that the interference of static electric field with the regulation of the cardiovascular system is primarily due to activation of the sympathetic nervous system. (3 refs.)

4808 ACTIVITY DYNAMICS OF LACTIC DEHYDROGENASE IN THE SKELETAL AND HEART MUSCLE AFTER A SINGLE EXPOSURE TO AN ALTERNATING CURRENT MAGNETIC FIELD. (Rus.) Udintsev, N. A. (Tomsk Medical Inst., Tomsk, USSR); Kanskaya, N. V.; Schepetilnikova, A. I.; Ordina, O. M.; Pichurina, R. A. *Biull. Eksp. Biol. Med.* 81(6): 670-672; 1976.

The activity, isoenzyme pattern, and intracellular distribution of lactate dehydrogenase (LDH) in the skeletal muscles and myocardium of male rats were studied 1 hr to 28 days after a single 24-hr exposure to an alternating current magnetic field (200 Oe, 50 Hz). The LDH activity in the skeletal muscle showed an increase from  $489 \pm 24$  to  $612 \pm 27$  mmol/min/g of tissue 1 hr after exposure; it remained at that level for 2 days and reached the control level after 28 days. Two days after exposure the percentage of H type LDH in the cytoplasm was 38.3% versus 66.4% in the control, and that of M type was 61.7% versus 33.6% in the control. These values returned to near normal in 7 days. Five isoenzymes were found in the mitochondria; the percentage of LDH<sub>5</sub> was 32.6% on the second day after exposure versus 51.7% in the control. The changes in the ratios of the other isoenzymes were less marked. Histologic examinations performed within 24 hr after exposure revealed dilatation of the capillaries, venules, and lymph vessels; perivascular edema; edema of the tissues; and vacuolization of the cytoplasm. The muscular tissue was nearly normal 28 days after exposure. The LDH activity of the myocardium increased during the first 2 days after exposure, and it normalized in 7 days. One hr after exposure type H accounted for 40.7% of the total activity in the cytoplasm, versus 76.4% in the control. Three isoenzymes were found in the mitochondria; LDH<sub>1,2</sub> showed a tendency to de-

crease 2 days after exposure. Marked dilation of the vessels, acidophilia of the cardiomyocytes, attraction of the nuclei to the sarcolemma, loss of the regular shape of the nucleus, and isolated focal subendocardial destruction were observed within 48 hr. These changes disappeared in 28 days. The findings indicate the activation of the glycolytic processes as a consequence of tissue hypoxia, which may be due to pronounced edema caused by disturbances in the blood and lymph circulation. (12 refs.)

4809 THE DEVELOPMENT OF HYPERTHERMIA MICROWAVE GENERATORS AND THERMOMETRY (MEETING ABSTRACT). (Eng.) Sandhu, T. S. (Roswell Park Memorial Inst., Buffalo, NY 14263); Kowal, H.; Johnson, R. J. *Int. J. Radiat. Oncol. Biol. Phys.* (Suppl. 1): 100; 1976.

To study the normal tissue and tumor response of superficial human tumors, regional hyperthermia and thermometry were developed. Initial animal and clinical studies were performed with a 2450 MHz microwave source using the intermediate field of a corner reflector type C applicator and foil collimation for localization. Thermometry showed that the tumor at 1 cm depth could be heated to 41-42°C with an exposed skin temperature of 41-42°C. A 915 MHz microwave generator that theoretically could almost triple the energy penetration was designed and built using a direct contact applicator separated from the skin by liquid dielectric in a bag. The liquid dielectric was circulated through a heat transfer unit to keep the skin at constant temperature. The steady flow rate and the temperature of incoming and outgoing liquid through the bag were recorded to measure the energy lost to the liquid. A thermometric device was developed using intratumor 30 gauge thermocouples, surface thermistors, and surface liquid crystal fibro optic units. It can be used to monitor the operating temperature and regulate the microwave output. (No refs.)

4810 PATHOGENESIS AND AGGRAVATION OF OCCUPATIONAL DISEASES CAUSED BY RAYS OF DIFFERENT WAVELENGTHS. (Ger.) Nikolowski, J. (Universitäts-Hautklinik, 74 Tuebingen, Liebermeisterstr. 25, W. Germany); Schuele, D. *Berufsdermatosen* 23(2): 55-61; 1975.

The effects of occupational exposure to ionizing and nonionizing radiation are reviewed. Exposure to high frequency and ultrahigh frequency radiation induces first- and second-degree burns, but there have been no cases reported of delayed effects on the skin from these sources. Cataracts may develop in persons exposed to infrared radiation. A case is cited in which first- and second-degree skin burns of the face and neck occurred in an engineer who had been exposed to an electromagnetic field. The field emanated from a generator operating at 500-2,000 kW (corresponding to 50,000 kW in the bundled beam) at 5-26 MHz and extending 500-2,000 m from the generator. (10 refs.)

# CURRENT LITERATURE

Biological Effects Nonionizing Electromagnetic Radiation 1(3), April 1977

- 4811 CIRCADIAN ACTIVITY RHYTHM INFLUENCED BY NEAR ZERO MAGNETIC FIELD. (Eng.) Bliss, V. L. (Dept. of Zoology, Univ. of Rhode Island, Kingston, RI 02881); Heppner, F. H. *Nature* 261(5559): 411-412; 1976.

The effect of a near zero magnetic field on the circadian rhythm of house sparrows (*Passer domesticus*) was investigated. Both experimental and control birds were maintained in a light-darkness 8:16-hr cycle and in the earth's normal magnetic field for the first 2 wk of the experiment. During the next 2 wk, all birds were maintained in the light-darkness 8:16 cycle, but the experimental birds were exposed to 8 hr of near 0 G magnetic field and 16 hr of the earth's magnetic field, with the 8 hr of near 0 G magnetic field synchronized with the 8 hr of light. For the last 4 wk, all birds were maintained in darkness, with the controls kept in the earth's magnetic field and the experimental birds kept in the near 0 G magnetic field. During the final 4 wk, the period length of most of the control birds became longer, and the onset of activity began later and later each day. This resulted in a large amount of activity from 1800-2400 hr. The activity period of the experimental birds lengthened in most cases, and this lengthening was due to the activity beginning earlier and ending later than it had while the light cycle was in operation. The experimental birds had a period length of 24 hr; however, the relative amplitude of the 24-hr period was less marked than in the light-darkness 8:16 cycle. The activity between 1800 and 2400 hr was significantly greater for the controls than for the experimental birds during the 4-wk total darkness period. The results indicate that circadian activity of the house sparrow may be entrained by a cycle of change in the intensity of the vertical component of the earth's magnetic field. (19 refs.)

- 4812 SUDDEN, UNEXPECTED DEATH OF INFANTS AND ELECTROMAGNETIC FIELDS. (Ger.) Eckert, E. E. (14 Green Briar Lane, Newtown, CT 06470). *Med. Klin.* 71(37): 1500-1505; 1976.

On-site investigations of 200 cases of crib death in Philadelphia, Pa., and 294 cases in Hamburg, West Germany, were conducted to assess the possible causal relationship between crib death and electromagnetic fields. The investigations in Philadelphia revealed a high incidence of crib death in buildings near electric railroad and subway lines, high-voltage power transmission lines, water mains magnetized by power supply lines, transmitting antennae, airports, and churches with lightning rods. The survey conducted in Hamburg revealed that the incidence of crib death was highest in temporary accommodations built near railroad and subway lines, and high-voltage transmission lines, especially when combined with high groundwater level. The risk of crib death was higher in cellars and first-floor apartments than in higher floors. The findings indicate a possible causal relationship between crib death and abnormal electromagnetic fields and stray currents in the ground. The findings warrant on-site measure-

ments and animal experiments on the effect of such fields and stray currents on animals. It is hypothesized that magnetic and/or electric fields provoke irreversible changes in the regulatory system of infants who are sensitive to such fields or have been sensitized by the fields. Since this effect is potentiated by the hypofunction of the organs during sleep, this hypothesis would account for the tendency of crib death to occur during sleep. (13 refs.)

- 4813 EFFECT OF CONSTANT MAGNETIC FIELDS ON MACROMOLECULES. (Rus.) Miroshnichenko, F. D. (Zaporozhye State Pedagogical Inst., Zaporozhye, USSR); Stadnik, A. D. *Biofizika* 21(1): 178-179; 1976.

The effect of constant magnetic field on macromolecules of polymethylmethacrylate was studied. Disks, measuring 2 mm in thickness and 20 mm in diameter, were heated to 100°C and simultaneously exposed to a constant magnetic field with intensities ranging from  $16 \times 10^{-3}$  to  $128 \times 10^{-3}$  amp/m for 60 min. The exposure to the constant magnetic field led to the development of a peculiar electric state with a surface charge density in the order of magnitude of  $10^{-10}$  Coul/cm<sup>2</sup>, depending on the field intensity. The appearance of the surface charges was due to the orientation of the magnetically anisotropic macromolecules and of their segments. The exposure caused a field intensity-dependent decrease in the magnetic susceptibility of the material probably due to the orientation in the magnetic field, which was accompanied by an increase in the polarization paramagnetism. It is concluded that the effects observed may explain some peculiarities of the mechanism of the effect of magnetic fields on biologic objects. (3 refs.)

- 4814 DEVELOPMENT OF RETICULOCYTOSIS IN THE PERIPHERAL BLOOD DURING AN EXPOSURE TO A CONSTANT MAGNETIC FIELD. (Rus.) Borodkina, A. G. (No affiliation given). *Kosm. Biol. Aviakosm. Med.* 10(1): 66-70; 1976.

The effect of constant magnetic fields on the reticulocyte count of the peripheral blood was studied in CBA mice. Exposure to a 1,000 Oe magnetic field for 1-3 hr or 1-15 days, or exposure to 4,500-5,000 Oe for 7.5 hr caused no changes in the erythrocyte count or in the hemoglobin level, but it increased the reticulocyte count. During the 15-day exposure to 1,000 Oe, the reticulocyte count peaked 2-3 days after the beginning of the exposure, reaching 246% of the control level, and dropped to 145% of the control value on day 5 and to the control value on day 15. Two days after the 15-day exposure the reticulocyte count rebounded to 235%—higher than the control group count on day 6. It is concluded that the hypoxia caused by the magnetic field leads to stimulation of the erythrocyte system and can be accompanied by the development of reticulocytosis, which is regarded as a typical manifestation of the reaction of the blood to constant magnetic field. (10 refs.)

- 4815 THE EFFECT OF SOME ANALEPTICS ON THE OUTCOME OF AN ACUTE MICROWAVE LESION IN MICE. (Rus.) Koldaev, V. M. (Vladivostok Medical Inst., Vladivostok, USSR). *Farmakol. Toksikol.* 39(5): 543-544; 1976.

The effect of analeptic agents on the survival time of microwave-irradiated mice was studied. Immediately after irradiation ( $62 \pm 5$  mW/cm<sup>2</sup>, wavelength 12.5 cm, duration 14-16 min), male albino mice were administered the following analeptics: strychnine nitrate, nicotinic acid diethylamide (Cordiamin, nikethamide), cytitone, camphor, caffeine sodium benzoate, corazol (pentylenetetrazole), and lobeline hydrochloride. The ratio of the survivals after irradiation + analeptic treatment to survival after irradiation alone was 1.48 for strychnine nitrate, 1.43 for nikethamide, 1.26 for cytitone, 1.16 for camphor, 1.16 for caffeine sodium benzoate, 1.07 for pentylenetetrazole, and 1.06 for lobeline hydrochloride. The optimal doses were determined to be 1 mg/kg for strychnine nitrate, 50 mg/kg for nikethamide, 5 mg/kg for cytitone, 200 mg/kg for camphor, 10 mg/kg for caffeine sodium benzoate, 20 mg/kg for pentylenetetrazole, and 50 mg/kg for lobeline hydrochloride. As the optimal dose of strychnine nitrate is close to its toxic dose, nikethamide is of the greatest therapeutic value among the substances tested. The findings indicate the favorable effect of the stimulation of the vital centers of the medulla oblongata on the outcome of acute exposure to microwaves. (4 refs.)

- 4816 THE CHANGES OF THE EVOKED CEREBRAL POTENTIALS DURING EXPOSURE TO A CONSTANT MAGNETIC FIELD. (Rus.) Klimovskaya, L. D. (No affiliation given); Smirnova, N. P. *Bull. Eksp. Biol. Med.* 82(8): 906-910; 1976.

The effect of a constant magnetic field (CMF; 500-4,000 Oe, 10-20 min) on the cerebrocortical and cerebellocortical potentials evoked by stimulation of the sciatic nerve was studied in Nembutal anesthetized albino rats. Exposure to the CMF caused increases in the latency period (12.5-16.5 msec in the cerebral cortex versus an initial value of 15 msec; 15.5-17 msec versus an initial value of 15.5 msec in the cerebellar cortex), in the first phase of the primary responses (164.7-197.4  $\mu$ V versus an initial level of 155.9  $\mu$ V in the cerebral cortex; 123.6-171.6  $\mu$ V versus 123.4  $\mu$ V in the cerebellar cortex), in the duration of the first phase of the primary response (from 22 msec to 19-23 msec in the cerebral cortex; from 26.5 msec to 22-26 msec in the cerebellar cortex), and the appearance of additional phases (1.9-4.9 phases versus 2.0 before exposure in the cerebral cortex, and 1.3-5.3 versus 1.5 in the cerebellar cortex). The maximal amplitude was 262.9-364.9  $\mu$ V in the cerebral cortex versus an initial amplitude of 239.8  $\mu$ V, and 138.7-336.8  $\mu$ V versus an initial value of 144.6  $\mu$ V in the cerebellar cortex. The effect of the CMF enhanced with increasing intensity between 400 and 5,000 Oe. (17 refs.)

- 4817 INHIBITING ACTION OF ELECTRIC FIELD ON *ESCHERICHIA COLI*. (Rus.) Sadovnichy, B. E. (Mordvin State Univ., USSR); Prytkova, T. N.; Sidorova, V. I. *Mikrobiologiya* 44(5): 948-949; 1975.

The effect of a stationary electric field with 300 V potential on the growth of *Escherichia coli* suspended in sterilized distilled water was studied. The exposure time to the electric field was 30 or 60 min. The effect of the exposure was determined by comparing the number of colonies after incubation for 24 hr at 24-25°C to a control. The experiments demonstrated a highly significant inhibition of the growth of *E. coli* by the stationary field. The inhibition intensified as the length of the exposure increased. (4 refs.)

- 4818 TREATMENT OF DISEASES OF LIMB STUMPS WITH ALTERNATING CURRENT MAGNETIC FIELD. (Rus.) Kucherenko, A. E. (Dept. Orthopedics, Traumatology and Field Surgery, N. I. Pirogov Vinnitsa Medical Inst., Vinnitsa, USSR); Shevchuk, V. I. *Klin. Khir.* (7): 47-49; 1976.

The effects of treatment with variable magnetic field (200-400 Oe) were studied in ninety 48- to 75-yr-old invalids with painful neuroma and edema of the limb stump and with phantom limb pain. Limb amputation had been performed 29-32 yr earlier. The limb stump was placed between the poles of the electromagnet. The therapy course consisted of 4-40 daily 15-min-sessions with an average of 18.2 sessions. Alleviation of edema, inflammation, and pain; normalization of sleep; improvement of the general well-being; and an increase in the surface temperature of the stump by 3.5-5°C were observed after the therapy. Increased bioelectric activity of the muscles of the stump was noted. Complete cure was achieved in 80 patients, considerable improvement in 6, and improvement in 4. Twenty-eight patients were able to resume the use of their prostheses. The findings indicate the therapeutic value of variable magnetic field in the treatment of diseases of limb stumps. (9 refs.)

- 4819 EFFECT OF ELECTROMAGNETIC FIELDS ON AIR IONIZATION. (Rus.) Miroshnichenko, L. I. (No affiliation given). *Vestn. Akad. Nauk. SSSR* (6): 105-106; 1976.

Highlights of a conference on "Physico-mathematical and Biological Problems of the Effect of Electromagnetic Fields and of Air Ionization" (Yalta, USSR, Nov. 25-28, 1975) are presented. Natural and artificial electromagnetic fields have been recognized as an important ecological factor. Electromagnetic fields have a differentiated effect on human organs; however, they have a direct effect on the nervous system. The ability of the human body to adapt itself to electromagnetic fields is limited in healthy subjects and impaired under pathologic conditions. The mode of action of electromagnetic fields on the body is unknown. The imposition of standards on artificial electromagnetic fields is suggested. (No refs.)

# CURRENT LITERATURE

Biological Effects Nonionizing Electromagnetic Radiation 1(3), April 1977

- 4820 EFFECTS OF ELECTRIC FIELDS ON LARGE ANIMALS: A FEASIBILITY STUDY. (Eng.) Phillips, R. D.; Richardson, R. L.; Kaune, W. T.; Hjerlesen, D. L.; Beamer, J. L.; Gillis, M. F. (Batelle Memorial Inst., Pacific Northwest Lab., Richland, WA 99352). 84 pp. [available through National Technical Information Services, Washington, DC. Document No. PB 251-632].

Experiments to determine the feasibility of and experimental conditions required for the long-term exposure of Hanford Miniature Swine to 60 Hz high-strength electric fields were conducted. The behavior of swine appeared normal at field strengths up to 50 kV/m. At 55 kV/m ear flicking was commonly observed, and one swine exhibited head shaking. No corona occurred on or near the swine at field strengths up to 55 kV/m. Minishocks were avoided at field strengths as high as 55 kV/m by maintaining the swine in a stall with nonconducting walls, by providing a metal ground plate for the animal to stand on, and by keeping the drinking water system at or close to ground potential. The threshold field strength for piloerection and hair oscillation was about 50 kV/m. The swine appeared to perceive electric fields at 30-35 kV/m without visible hair movement. Electric field measurements made with and without the swine in the electric field indicated that the field was markedly altered in the vicinity of the swine's body, emphasizing the need for more complete and detailed dosimetry if results from studies with experimental animals are to be used for establishing human exposure limits. Data for the design of a full-scale prototype configuration for investigating the possible biologic effects of exposure to high strength electric fields were obtained. (4 refs.)

- 4821 EMC DESIGN EFFECTIVENESS IN ELECTRONIC MEDICAL PROSTHETIC DEVICES. (Eng.) Mitchell, J. C.; Hurt, W. D.; Steiner, T. O. In: *Fundamental and Applied Aspects of Nonionizing Radiation*. Michaelson, S. M.; Miller, M. W.; Magin, R.; Carstensen, E. L., eds. (New York: Plenum Press): pp. 351-363; 1974.

Cardiac pacemakers were tested to assess the extent of radiofrequency electromagnetic radiation interference (EMI) possible from a variety of radiofrequency (RF) sources. Seventy pacemakers with 21 different designs and from 10 manufacturers were tested. Radiation sources included laboratory generators operating at pulsed frequencies of 450 and 3100 MHz, various household electric devices, and the RF emission from an automobile ignition. The pacemakers were tested in free-field and simulated-implant configurations for each of the radiation sources. Relative interference thresholds were vastly different, with the most sensitive pacemaker adversely affected at electric (E) field levels as low as 10 V/m and the least sensitive pacemaker relatively free of interference at levels as high as several hundred V/m. In many cases the real time E-field level around RF radiation emitters manifested itself as a pulsed or pseudo-pulsed (chang-

ing E-field level) signal, which could adversely affect cardiac pacemakers and was potentially hazardous for other types of medical prosthetic devices. It is concluded that pacemaker manufacturers will eventually resolve most of the potential pacemaker EMI problems. The authors recommend that manufacturers of other medical instrumentation and electronic prostheses incorporate good EMI rejection techniques in all new devices. (12 refs.)

- 4822 GROWTH AND DEVELOPMENT OF NEONATAL MICE EXPOSED TO HIGH-FREQUENCY ELECTROMAGNETIC FIELDS. (Eng.) Stavinoha, W. B.; Modak, A.; Medina, M. A.; Gass, A. E. (Univ. Texas Health Science Center at San Antonio, 7703 Floyd Curl Drive, San Antonio, TX 78284); 8 pp., 1975. [available through National Technical Information Services, Washington, DC, Document No. SAM-TR-75-51].

The effects of radiofrequency (RF) radiation on the growth and development of neonatal rodents were investigated in two studies. In the first experiment, 4-day-old Swiss Webster mice, in plastic containers, were exposed to 10.5, 19.27, and 26.6 MHz RF radiation for 20 min. The measured electric field was approximately 5800 V/m. Controls were kept in similar containers outside the exposure chambers. The animals were weighed daily to the nearest milligram for the following 21 days. In the second study, 4-day-old Swiss Webster mice were divided into three groups: (1) control mice, kept in individual cages; (2) thermal control mice, exposed to an environment of 37°C for 40 min for 5 consecutive days; and (3) irradiated mice, exposed to RF radiation at 19 MHz for 40 min for 5 consecutive days. Following exposure, the mice were weighed for 16 wk. No significant differences in growth and development were observed among the irradiated and nonirradiated mice in both studies. It is concluded that nonionizing radiation at the frequencies used had no effect on neonatal mouse growth. The authors point out, however, that since the size of the mice was much smaller than the wavelengths used, their bodies probably absorbed only a relatively small amount of energy. (9 refs.)

- 4823 COMPARISON OF IONIZING AND MICROWAVE RADIATIONS WITH RESPECT TO THEIR EFFECTS ON THE RODENT EMBRYO AND FETUS (ABSTRACT). (Eng.) Rugh, R. (U.S. Dept. Health, Education, Welfare, Public Health Service, Food and Drug Admin., Bureau Radiological Health, 5600 Fishers Lane, Rockville, MD); McManaway, M. *Teratology* 14(2): 251; 1976.

Rodent fetuses and embryos, exposed to nonionizing electromagnetic radiation from conception to organogenesis, were studied for the development of congenital anomalies. A radiation frequency of 2450 MHz was employed within a waveguide at a forward power of 7.5 W, at an average absorbed dose rate of 78.8-136.2 mW/g and a mean value of 107.4 mW/g. The incidence of congenital anomalies among rodent fetuses exposed for 4 min was highest at 8 and 10 days gestation. Teratogenesis followed both ionizing and

electromagnetic radiation exposures at comparable gestation stages, indicating the inherent radio-sensitivity of embryos and fetuses. There was essentially no thermal stress with ionizing radiation and no ionizations with microwave heat energies. For humans, hypersensitivity stages correspond to gestation days 9 and 20. (No refs.)

- 4824 AN APPROACH TO BIOLOGICAL RESPONSE TO MICROWAVES: A PRELIMINARY THERMAL VERSUS NON-THERMAL EXPERIMENT. (Eng.) Wayland, J. R.; Brannen, J. P.; Morris, M. E. (Sandia Lab., Albuquerque, NM 87115). 18 pp; 1975. [available through Sandia Laboratories, Albuquerque, NM, Document No. SAND75-0494].

The separation of thermal and non-thermal effects in response to microwave radiation was studied using spore inactivation rate of *Bacillus subtilis* var *niger* as the measurable response. Dry spore stock in a quartz tube was exposed to microwave radiation at a frequency of 2450 MHz over power levels ranging from 9-30 kW. Thermal effects on inactivation were measured during dry heat inactivation, and the temperature during exposure to microwave energy was monitored by infrared microscopy. A comparison of the reaction rate constants versus power for heat alone and for exposure to microwaves revealed a non-thermal effect that was evidenced by a difference in the spore inactivation rate constants. (9 refs.)

- 4825 THE INSENSITIVITY OF FROG HEART RATE TO PULSE MODULATED MICROWAVE ENERGY. (Eng.) Liu, L. M. (Dept. of Biophysics, Medical Coll. of Virginia, Richmond, VA 23298); Rosenbaum, F. J.; Pickard, W. F. *J. Microwave Power* 11(3): 225-232; 1976.

The effect of pulse modulated microwave irradiation on the heart rate of the frog (*Rana pipiens*) was investigated. Two types of experiments were conducted. In one, frog hearts were irradiated *in situ* with 100  $\mu$ sec bursts at a carrier frequency of either 10.0 GHz or 1.42 GHz at an average power delivered to the vicinity of the heart of either 16  $\mu$ W or 12  $\mu$ W, respectively. In a second experiment, isolated frog hearts were irradiated with 100  $\mu$ sec bursts at a carrier frequency of 1.42 GHz and an average power (delivered to the vicinity of the heart) of 7  $\mu$ W. No significant changes in heart rate were observed during either experiment. A comparison of the above negative results with similar experiments, which led to the production of tachycardia in isolated frog hearts, and performed by other investigators is made. It is concluded that the rate of energy absorption, though virtually unmeasurable with either a horn or a microprobe, may be of crucial importance and that, if an optimal dosage for the production of arrhythmias does exist, then it points toward the presence of a putatively athermal effect that is different from that implicated in the teratogenic action of microwaves. (12 refs.)

- 4826 A REPLY TO THE CONCEPT OF CANCER TREATMENT BY NMR (LETTER TO EDITOR). (Eng.) Reisse, J. (Chimie Organique E. P., Université Libre de Bruxelles, 50, avenue F.D. Roosevelt, B 1050 Bruxelles, Belgium); Piccinni-Leopardi, C. *Physiol. Chem. Phys.* 8(2): 175-176; 1976.

The authors claim that a proposal advanced by Zaner and Damadian [*Physiol. Chem. Phys.*, 7, 437 (1975)] to irradiate tumors at "cancer specific frequencies" to selectively kill cancer cells is totally unrealistic. The proposal contended that a large scale radiofrequency (RF) source ("cavity resonator") could be constructed to provide a homogeneous field [with a homogeneity of a few parts per million (ppm) since the frequency differences between normal and cancer absorptions are of this magnitude] to irradiate the subject at "cancer specific frequencies" and selectively kill only neoplastic tissue and leave normal tissue unharmed. It is argued, however, that it is impossible to effect a selective increase in the temperature of cancer cells by subjecting a patient to RF irradiation. It is pointed out that Zaner and Damadian overlooked the fact that cancer specific absorption frequencies only existed because their test sample had been exposed to a very homogeneous magnetic field. With no magnetic field, specific absorptions would not exist either for cancer cells or for normal cells; only a non-specific absorption of RF radiation would be present. This non-specific absorption can be described as the result of dielectric loss. The patient would consequently be exposed not only to a "cavity resonator" but to a strong magnetic field. Moreover, this magnetic field would be extremely homogeneous since the difference between the absorption frequencies of normal and cancer tissues is a few ppm. The homogeneity of the field must therefore be superior to 1 ppm to maintain a distinction between normal and "cancer absorptions." It is concluded that, given the extreme difficulty which is encountered in obtaining such magnetic characteristics in a volume of 2 or 3 milliliters between the poles of an electromagnet (the poles having been set a few centimeters apart), it is apparent that the concept of an electromagnet, which could contain a man, even partially, is totally unrealistic. (1 ref.)

- 4827 A REPLY TO THE CONCEPT OF CANCER TREATMENT BY NMR (AUTHOR'S REBUTTAL) (LETTER TO EDITOR). (Eng.) Zaner, K. S. (No affiliation given); Damadian, R. *Physiol. Chem. Phys.* 8(2): 176; 1976.

The authors state that critics of their proposal to irradiate tumors at cancer specific frequencies failed to consider the possibility that the 2-milliliter spot of high uniformity, which they cite, could be moved through the patient. Therefore, the entire field need not satisfy a stringent high-resolution requirement. This is the basis of the FONAR (field focusing NMR) method for nuclear resonance imaging. (1 ref.)

CURRENT LITERATURE

- 4828 DIELECTRIC PROPERTIES OF BIOLOGICAL MATERIALS AND INTERACTION OF MICROWAVE FIELDS AT THE CELLULAR AND MOLECULAR LEVEL. (Eng.) Schwan, H. P. In: *Fundamental and Applied Aspects of Non-ionizing Radiation*. Michaelson, S. M.; Miller, M. W.; Magin, R.; Carstensen, E. L., eds. (New York: Plenum Press): pp. 3-19; 1974.

Dielectric properties of biologic materials are reviewed and discussed in terms of the interaction of microwave fields at the cellular and molecular level. Forces that are caused by alternating fields are not likely to be significant at the molecular and microscopic cellular level unless huge field strength values are assumed--values so large that accompanying thermal effects may be significant. However, on a macroscopic level, these effects may well be significant. The phenomenon of hearing pulsed microwave fields may be explained by the forces rhythmically applied to the middle ear structures as the field is turned on and off. Therefore, forces which can be generated by the application of alternating fields (field evoked forces, dielectrophoresis, electromechanical effects) deserve consideration and may be responsible for the phenomenon of hearing pulsed field and also for some of the behavioral effects reported in the 1-10 mW/cm<sup>2</sup> range. There appears to be no basis for anticipating thermal effects below about 1 mW/cm<sup>2</sup>, and any effects evoked by fluxes below this power level appear to be of the nonthermal type. (20 refs.)

- 4829 MICROWAVE AUDITORY EFFECT--A COMPARISON OF SOME POSSIBLE TRANSDUCTION MECHANISMS. (Eng.) Lin, J. C. (Dept. Electrical and Computer Engineering, Wayne State Univ., Detroit, MI 48202). *J. Microwave Power* 11(1): 77-81; 1976.

First order calculations were used to compare three possible physical mechanisms that may be involved in the auditory effects of pulse-modulated microwave radiation. The forces due to radiation pressure, strictive forces, and rapid thermal expansion were compared using a simple one-dimensional model that assumed uniform power absorption at and near the surface of the lossy dielectric body. A comparison of the magnitude of the acoustic energy generated by the radiation pressure, strictive force, and thermal expansion revealed that thermally induced forces exceeded radiation pressure by a large margin. While the strictive forces were high in comparison with radiation pressure, they were much smaller than thermal expansion in both water and muscle material. If a 6% coupling efficiency and a peak absorbed power density of 2400 W/m<sup>2</sup> (the minimally effective value for 2450 MHz microwave radiation to produce audible signals in an adult with normal hearing) are assumed, the computed maximum stress is approximately 0.02 Newtons-m<sup>2</sup> for both muscle and brain. This value is above the previously established threshold of hearing for bone conduction. The results indicate that while all three forces are capable of producing auditory effects, the stress resulting from thermal expansion may be so great that it completely masks the effects of radiation

pressure and strictive force. The authors conclude that the amplitude of the stress-generated acoustic signal is of such magnitude that it represents a probable explanation of the microwave pulse-induced auditory phenomenon in man. (19 refs.)

- 4830 MEMBRANE-BOUND ATP SYNTHESIS GENERATED BY AN EXTERNAL ELECTRICAL FIELD. (Eng.) Witt, H. T. (Max-Volmer-Institut fuer Physikalische Chemie und Molekularbiologie, Technische Universitaet Berlin, 1000 Berlin 12, Strasse des 17. Juni 135, Germany); Schlodder, E.; Graeber, P. *FEBS Lett.* 69(1): 272-276; 1976.

An external electrical field was used to generate membrane-bound adenosine triphosphate in isolated spinach chloroplasts. The chloroplasts were suspended in a cuvette between 2 platinum electrodes. Voltage pulses (30 msec pulse width) of 220 V were applied to the electrodes, corresponding to an external electrical field strength of  $1.1 \times 10^3$  V/cm. The amount of adenosine triphosphate/chlorophyll generated by the external voltage pulses increased linearly with increasing numbers of pulses, and the yield of adenosine triphosphate was  $7.6 \times 10^{-3}$  mole/mole of chlorophyll. Assuming that there existed one adenosine triphosphatase per 860 chlorophyll molecules, at least 6.5 adenosine triphosphate molecules were synthesized per adenosine triphosphatase by the external electrical pulses. Substances that inhibit the reaction of the adenosine triphosphatase inhibited adenosine triphosphate formation when the electrical field was applied, and substances that inhibit light-induced linear electron flow did not affect adenosine triphosphate formation, indicating that the measured adenosine triphosphate was not the result of artefacts. Hence, an artificial electrical potential difference alone was sufficient to generate phosphorylation with yields comparable to those induced by light under natural conditions. (27 refs.)

- 4831 MICROWAVE-INDUCED HEARING: SOME PRELIMINARY THEORETICAL OBSERVATIONS. (Eng.) Lin, J. C. (Electrical and Computer Engineering Dept., Wayne State Univ., Detroit, MI 48202). *J. Microwave Power* 11(3): 295-298; 1976.

A theoretic analysis of microwave-induced auditory sensation is presented. It is shown that the frequency of cochlear microphonics recorded from the round window of guinea pigs is the same as the fundamental frequency of vibration (50 kHz) of a spherical model of the guinea pig's head consisting only of brain matter. The model was exposed to pulsed microwave radiation at a frequency of 918 MHz. The auditory phenomenon is believed to arise from the rapid temperature rise in the brain as a result of microwave absorption. This negligible temperature rise, which occurs in a very short time, creates thermal expansion of the brain matter and launches the acoustic signal that is detected by the cochlea and is received by bone conduction. (8 refs.)

- 4832 HISTOMORPHOLOGICAL STUDY OF WOUND REGENERATION IN ANIMALS FOLLOWING LONG-TERM EXPOSURE TO LOW-INTENSITY MICROWAVES. (Eng.) Shaposhnikov, Yu. G. (Dept. Surgery, Central Postgraduate Medical Inst., Moscow, USSR); Yares'ko, I. F.; Vernigora, Yu. V. *Bull. Exp. Biol. Med.* 80(8): 988-990; 1976.

Wound regeneration was studied *in vitro* in guinea pigs following long-term exposure to low-intensity microwave irradiation. Linear wounds 5 cm long were incised down to the dermis in the dorsal region of 80 guinea pigs (30 of them controls) following exposure to 5 mW/cm<sup>2</sup> microwave irradiation (experimental group only). The animals were killed on days 3, 5, 7, 9, and 11 following wound incision. The skin flap containing the wound and postoperative scar was excised, and the wound area was investigated histologically. The wounds in the irradiated and nonirradiated groups healed by first intention. In the explants of the irradiated animals, killed on the third postoperative day, regeneration of the epithelium was stimulated and granulation tissue developed intensively in the lower parts of the tissue. Tensimetric readings (in g) of the scars were  $220 \pm 2.3$  ( $p < 0.001$ ) for nonirradiated animals compared with  $344 \pm 2.7$  ( $p < 0.001$ ) for the irradiated animals. In the explants of irradiated animals, killed on the fifth postoperative day, proliferating fibroblasts were rich in RNA, and an increased content of acid mucopolysaccharides was found in the ground substance indicating active synthesis of proteins, including collagen. In the explants of irradiated animals, killed on days 7 and 9, young connective tissue formed in the place of the granulation tissue, and it was more mature than in the unirradiated animals. In the eleventh-day explants, the wound edges were completely united throughout their depth in the irradiated and nonirradiated animals. In the irradiated animals the scar tissue differed only slightly from the surrounding connective tissue. However, in the lower parts of the tissue of the controls, the regenerating connective tissue was not yet mature. Tensimetric readings of the eleventh day explants were  $1100 \pm 2.7$  for the controls compared with  $1420 \pm 2.6$  ( $p < 0.001$ ) for the experimental group. It is concluded that microwave irradiation improved wound healing. (3 refs.)

- 4833 IMMUNOREACTIVE LUTEINIZING HORMONE RELEASING FACTOR IN PITUITARY STALK BLOOD FROM FEMALE RATS: SEX STEROID MODULATION OF RESPONSE TO ELECTRICAL STIMULATION OF PREOPTIC AREA OR MEDIAN EMINENCE. (Eng.) Sherwood, N. M. (Dept. Biology, Univ. Victoria, Victoria, British Columbia, Canada V8W 2Y2); Chiappa, S. A.; Fink, G. *J. Endocrinol.* 70: 501-511; 1976.

The effects of sex steroid hormones on the responsiveness of the neural mechanism responsible for the secretion of luteinizing hormone releasing factor (LH-RF) were examined in female Wistar rats. Responsiveness was determined at proestrus by measuring the increments in immunoreactive LH-RF of pituitary stalk blood produced by electrical stimulation of

the medial preoptic area or median eminence. The stimulus used consisted of 30 sec trains of accurately balanced biphasic square-wave pulses with a frequency of 60 Hz, a pulse amplitude of 500  $\mu$ A (1 mA peak-to-peak), and a pulse duration of 1 msec. Ovariectomy on the morning of diestrus reduced the LH-RF response to preoptic stimulation, while estradiol benzoate (OB; 2.5 or 10  $\mu$ g) or testosterone propionate (TP; 2.5 mg) administered immediately after ovariectomy significantly augmented the response ( $p < 0.05$  and  $p < 0.05$ , respectively). The facilitatory effect of TP was possibly due to its conversion to an aromatized derivative since 5 $\alpha$ -dihydrotestosterone monobenzoate (2.5 mg) was ineffective. Progesterone (2.5 mg) did not facilitate preoptic responsiveness, and, when administered to animals ovariectomized at 12.00 hr of proestrus, reduced the LH-RF response at 18.00 hr the same day. Stimulation of the median eminence produced a significantly greater increment ( $p < 0.05$ ) in LH-RF than stimulation of the preoptic area. The facilitatory action of OB on the LH-RF response was less marked for median eminence compared with preoptic stimulation. The administration of the antiestrogen, ICI 46474 (0.5 mg), at 17.00 hr of dioestrus did not reduce preoptic responsiveness on the morning of the next day, suggesting that this compound does not act as an "antiestrogen" at the level of the preoptic area. It is concluded that, as assessed by the release of immunoreactive LH-RF, sex steroids facilitate the responsiveness of preoptic neurones to electrical stimulation. (57 refs.)

- 4834 POLARIZATION OF FUCOID EGGS BY STEADY ELECTRICAL FIELDS. (Eng.) Peng, H. B. (Dept. Biological Sciences, Purdue Univ., West Lafayette, IN 47907); Jaffe, L. F. *Dev. Biol.* 53: 277-284; 1976.

The effects of electrical fields on rhizoid initiation in fucoid eggs were investigated. *Pelvetia* eggs were exposed to steady electric fields from 5 hr after fertilization and were kept on for 12 hr. When the field was shut off, 95% germination was observed. Eleven batches of eggs responded by initiating rhizoids towards the positive electrode; two batches responded by growing towards the negative electrode; and three grew towards the negative one in small fields and towards the positive one in higher fields. Polarization, defined as the average cosine of the outgrowth directions, was proportional to field strength up to polarization values of 50% for the positive responses and 75% for the negative ones. A voltage drop of 6 mV/cell induced 10% polarization in the positively galvanotropic batches, while 3 mV/cell did this in the negative ones. It is concluded that both responses were mediated by faster calcium entry at the future growth point. It was faster there in positively galvanotropic eggs because the membrane potential, and therefore the driving force, was highest. In negatively galvanotropic eggs it was faster because depolarization induced an overbalancing increase in calcium permeability. (19 refs.)

# CURRENT LITERATURE

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- 4835 DIELECTRIC INCREMENT OF LOW MOLECULAR WEIGHT RNA IN DIOXANE AFTER APPLICATION OF STATIC ELECTRIC FIELDS. (Eng.) Galzigna, L. (Inst. Biological Chemistry, Univ. Padova, 35100 Padova, Italy); Garbin, L.; Pagura, C. *Biochim. Biophys. Acta* 447(2): 230-237; 1976.

Static electric fields were applied to an RNA solution to study changes of the permanent polarization of the RNA molecules. A soluble RNA with a molecular weight between 15,000 and 23,000 was extracted from calf thymus and chromatographically purified. The RNA was slightly soluble in dioxane (approximately 2.5 µg/ml) and RNA-dioxane solutions were used to fill a cell (452.02 pF capacitance) to which 5-60 kV/cm static electric fields were applied. The RNA solutions showed dielectric increments proportional to the strength of the applied field and to the RNA concentration. The existence of a hysteresis was proven, and the effect of the electric field on the RNA molecule might be related to a dielectric saturation phenomenon parallel to long-term changes of the molecule. The results suggest that it is possible to consider macromolecules analogous to those used in this experiment as devices suitable for the storage of a record of electric events for a considerable length of time. Further studies are in progress to quantitate the time-course of these processes and the type of structural transitions presented by the RNA in dioxane. (19 refs.)

- 4836 THE *IN VIVO* EFFECTS OF 2.45 GHZ MICROWAVE RADIATION ON RABBIT SERUM COMPONENTS AND SLEEPING TIMES. (Eng.) Wangemann, R. T. (USA Environmental Hygiene Agency, Laser Microwave Div., Aberdeen Proving Ground, MD 21010); Cleary, S. F. *Rad. Environ. Biophys.* 13: 89-103; 1976.

The effects of relatively low power density microwave exposures on various serum components were studied in 6- to 10-month-old Dutch rabbits weighing  $2.09 \pm 0.29$  kg. Both continuous wave and pulsed mode 2-hr exposures at 2.45 GHz were used at power densities of 25, 10, and 5 mW/cm<sup>2</sup>. Blood chemistry studies were performed on the following serum components: calcium, inorganic phosphate, glucose, blood urea nitrogen (BUN), uric acid, cholesterol, total protein, alkaline phosphatase, lactic dehydrogenase, and serum glutamic oxalic transaminase. Samples were taken prior to exposure, immediately postirradiation, and at 1, 2, and 7 days after exposure. Gross and histopathologic examinations were performed on representative samples of animals. Statistically significant and consistent changes were noted in glucose, BUN, and uric acid following microwave exposure. The response appeared to be dose-dependent with increases of 44% in animals exposed at 25 mW/cm<sup>2</sup>, continuous wave (CW); 29% in animals exposed to 10 mW/cm<sup>2</sup>, CW; and 18% in animals exposed at 5 mW/cm<sup>2</sup>, CW. Other serum components did not show consistent variation from baseline values. Observed physiologic response, as well as rectal temperature measurements, indicated that the thermoregulatory capability of the rabbits was sufficient to compensate for the thermal burden at 5 and 10 mW/cm<sup>2</sup> but could be overridden by a 2-hr

exposure at 25 mW/cm<sup>2</sup>. Pathology findings included a mild, repairable nephrosis in animals exposed at a power density of 25 mW/cm<sup>2</sup>. A further investigation of analeptic effects in phenobarbital-sedated rabbits at power densities varying from 5-50 mW/cm<sup>2</sup> resulted in a statistically significant decrease in sleeping times, apparently proportional to power densities below 15 mW/cm<sup>2</sup>. It is concluded that the results of the blood chemistry and sleeping time experiments were consistent with a dose-dependent response to a nonspecific thermal stress at all power densities used. (9 refs.)

- 4837 MICROWAVE HAZARDS. (Eng.) Anonymous. (No affiliation given). *Lancet* 2(7977): 135; 1976.

The discrepancy between the microwave exposure standards of the United States and Western Europe and of Russia and Eastern Europe is discussed. Western concern over U.S. embassy diplomats in Moscow who were exposed to Soviet directed microwave beams is noted. However, it is pointed out that the exposure levels at the embassy, which had been as high as 30 µW/cm<sup>2</sup>, were lower than the U.S. and British exposure standard of 10 mW/cm<sup>2</sup>. In Soviet usage, 10 mW/cm<sup>2</sup> is regarded as high-intensity radiation, and they claim that even low-intensity microwave radiation will lead to neurasthenia. Rather than to induce this syndrome, the author contends, it is more likely the Soviets sought to jam American listening devices. The author concludes that this affair serves to support the need for additional studies recommended by the World Health Organization on world-wide microwave exposure standards. (4 refs.)

- 4838 RADIO AND MICROWAVE RADIATION AND EXPERIMENTAL ATHEROSCLEROSIS. (Eng.) Sparks, H. V. (Dept. Physiology, Univ. Michigan Medical Sch., Ann Arbor, MI 48104); Mossman, D. L.; Seidel, C. L. *Atherosclerosis* 25: 55-62; 1976.

Aortic wall injury caused by radiofrequency and microwave irradiation and potential atherogenesis enhancement was studied in diet-induced atherosclerotic rabbits. Two sets of 16 New Zealand white rabbits were exposed to microwave (2.45 GHz) radiation at a power density of 20-30 mW/cm<sup>2</sup> for 4 hr a day, 5 days a week for 8 to 10 wk. Each set was divided into an experimental irradiated group and a control group. Following irradiation, the serum cholesterol concentrations, aortic wall cholesterol concentrations, and percentage of intimal surface involved in atherosclerotic lesions of the experimental animals did not differ significantly from the indices of age and weight matched controls. Continuous radiofrequency irradiation (1 MHz) for 8 to 11 wk with a field strength of 30 V/cm also failed to change these indices of atherogenesis. It is concluded that radiofrequency and microwave irradiation do not affect the course of diet-induced atherogenesis. (11 refs.)

- 4839 THRESHOLD EFFECTS OBSERVED IN CONFORMATION CHANGES INDUCED BY ELECTRIC FIELDS. (Eng.) Poerschke, D. (Max Planck Institut für Biophysikalische Chemie, 34 Goettingen, W. Germany). *Biopolymers* 15(10): 1917-1928; 1976.

Single-stranded polynucleotides were used as model systems for the investigation of conformational changes induced by electric fields. It was demonstrated that the single-strand helix-coil transition in poly(A), poly(dA), and poly(C) can be induced by application of high electric fields. The transition was measured by UV absorbance using polarized light at an angle of 54.8° with respect to the vector of the electric field and by electrochromism. A linear increase of the absorbance, reflecting the helix-to-coil transition, was observed at increasing field strength. When ions were added to the polymer, electric fields did not induce conformational changes, unless a threshold value of the electric field strength  $E_0$  was exceeded. At field strengths above this threshold, the degree of transition was a linear function of the increase in field strength. The threshold values  $E_0$  showed a linear increase with the logarithm of the ion concentration. Bivalent ions caused thresholds at much lower ion concentrations than monovalent ions. The shielding efficiency of ions was corrected to the binding affinity of these ions to the polymer. It is concluded that the conformation changes induced by the field and the existence of thresholds can be explained on the basis of dissociation field effects. Similar threshold effects may be expected for other macromolecules as well as for membrane structures and may be important in the regulation of bioelectricity. (28 refs.)

- 4840 COMBINATION RADIATION THERAPY AND LOCALIZED CURRENT FIELD HYPERTHERMIA OF SPONTANEOUS MALIGNANT NEOPLASMS OF ANIMALS. A PRECLINICAL STUDY (MEETING ABSTRACT). (Eng.) Day, P. W. (Univ. New Mexico, Sch. Medicine, Albuquerque, NM); Sternhagen, C. J.; Doss, J. D.; Edwards, S. *Int. J. Radiat. Oncol. Biol. Phys.* (Suppl. 1): 99; 1976.

One cat and two dogs with spontaneous malignant neoplasms were treated by combination radiation therapy and non-invasive localized current field (LCF) hyperthermia. The neoplastic area was covered by a copper pad surface electrode. A second large electrode was placed on the bottom of a saline water bath with an electrical resistivity of 500 ohms cm. The animal was then placed in the saline water bath until 25% of its surface was immersed with no direct contact of the second electrode. The first dog had a fibrosarcoma located on the right anterolateral nasopharynx. The tumor and surrounding area received 5 LCF treatments at 43°C for 30 min and 750 rads within 10 min of terminating hyperthermia. The animal showed no evidence of disease 3 mo post-treatment. The cat had a squamous cell carcinoma of long standing located in the medial canthus of the right eye. The tumor area received 4 LCF treatments at 43°C and 700 rads within 10 min of terminating hyperthermia. The tumor regressed for 12 wk with

granulation type healing in the treatment area. The second dog had a fibrosarcoma located in the left posterolateral hard palate involving the left molar teeth. The tumor area and surrounding tissues received 4 LCF treatments at 43°C for 30 min and 750 rads within 10 min of the terminating hyperthermia. The tumor area regressed continuously for 8 wk at which time the owner had the animal euthanized. Previous to the combination hyperthermia and radiation study, 14 animals with spontaneous neoplasms were treated with LCF alone. Thirty-three percent of the cases have had no recurrence of disease for 1 to 3 yr following treatment; forty-five percent of the tumors regressed with the animal returning to normal function. (No refs.)

- 4841 PRELIMINARY CLINICAL RESULTS OF 433 MEGAHERTZ MICROWAVE THERAPY AND RADIATION THERAPY ON PATIENTS WITH ADVANCED CANCER (MEETING ABSTRACT). (Eng.) Hornback, N. B. (Dept. Radiation Therapy, Indiana Univ. Sch. Medicine, 1100 West Michigan St., Indianapolis, IN); Shupe, R.; Shidnia, H.; Joe, B. T.; Sayoc, E. M. *Int. J. Radiat. Oncol. Biol. Phys.* (Suppl. 1): 102-103; 1976.

Several patients with advanced head and neck and gynecologic cancers who failed to respond to surgery, radiation, and/or chemotherapy were treated with hyperthermia and low dose radiation therapy. Each daily dose of 100 to 200 rads to localized fields was preceded by 10 to 20 min of hyperthermia using a 433 MHz RF generator. Total dose varied from 2000 to 5000 rads, depending upon response and condition of the patient. Early treatment results confirmed the previously described synergism between thermal radiation and ionizing radiation as manifested by subjective and objective improvements of patients. (No refs.)

- 4842 THE EFFECT OF POST-RADIATION HYPERTHERMIA ON HUMAN SKIN AND TUMOR RESPONSE (MEETING ABSTRACT). (Eng.) Johnson, R. (Roswell Park Memorial Inst., Buffalo, NY); Dosi, K. S.; Song, S. Y.; Sandhu, T. S.; Boyle, D. *Int. J. Radiat. Oncol. Biol. Phys.* (Suppl. 1): 98; 1976.

Ten melanoma patients with multiple superficial metastases were treated with orthovoltage X-rays using 3-6 fractions in 2-3 wk. Regional heat was applied immediately after radiation for 2 hr at 41-42°C using a 2450 MHz microwave generator. Multiple control lesions were treated with identical field size and fractionation but varying total doses. Surface thermistors and intratumor 30 gauge needle thermocouples were used for thermometry together with a liquid crystal fiberoptic unit to monitor operating surface temperature. The skin responses were scored, and tumor responses recorded for 40 separate tumors. No skin reaction occurred in the areas exposed to heat alone to 41-42°C to a depth of 1 cm. The skin radiation reaction was significantly increased in the heated lesions. (No refs.)

# CURRENT LITERATURE

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- 4843 *IN VITRO* EPIPHYSEAL-PLATE GROWTH IN VARIOUS CONSTANT ELECTRICAL FIELDS. (Eng.) Brighton, C. T. (Dept. Orthopedic Surgery, Univ. Pennsylvania Sch. Medicine, Philadelphia, PA); Cronkey, J. E.; Osterman, A. L. *J. Bone Joint Surg. (Am.)* 58(7): 971-978; 1976.

The effect of electric fields on bone growth was studied in an *in vitro* epiphyseal-plate model, obtained from the costochondral junction of a 21-day-old male Sprague-Dawley rat. Explants were grown for 10 days at 0, 500, 1000, 1500, 2000, 2500, and 3000 V/cm. The percent total elongation of the epiphyseal-plate was significantly greater ( $p < 0.01$ ) at 500 V/cm than that of controls. The percent total elongation increased with each voltage increment, reached a maximum at 1500 V/cm ( $p < 0.0005$ ), and declined at higher voltage gradients. The percent elongation of the bone portion of the explants followed the same pattern. The percent elongation of the cartilage portion of the explants reached a maximum at 1500 and 2000 V/cm ( $p < 0.0005$ ) and became less than that of the control group at 2500 and 3000 V/cm ( $p < 0.01$  and  $p < 0.001$ , respectively). The incorporation of  $^{45}\text{Ca}$  was significantly increased over that of the control group only at 1500 V/cm ( $p < 0.005$ ), while the incorporation of  $^{35}\text{S}$  was significantly increased over that of the control group at both 1000 ( $p < 0.01$ ) and 1500 ( $p < 0.05$ ) V/cm. The incorporation of  $^3\text{H}$ -thymidine was significantly increased over that of the control group only at 1500 V/cm ( $p < 0.001$ ). Histologic examination revealed few discernible differences between the various experimental groups and the controls. Although the mechanism of action of the electrical field on bone growth is not known, the authors suggest that the voltage gradient, either directly or indirectly, incites a physiologic response of the growth-plate chondrocyte. (135 refs.)

- 4844 THE TRANSMISSION OF REFLEXES IN THE SPINAL CORD OF CATS DURING DIRECT IRRADIATION WITH MICROWAVES. (Eng.) McRee, D. I. (Natl. Inst. Environmental Health Sciences, Res. Triangle Park, NC); Wyatt, R. H.; Haseman, J. K.; Somjen, G. *J. Microwave Power* 11(1): 49-60; 1976.

The spinal cord of cats was directly exposed to continuous microwave radiation at a frequency of 2.45 GHz to study the effect of such radiation on reflex response and synaptic function. During initial pilot experiments, no obvious differences in electrophysiologic recordings taken before, during, or after irradiation by microwave energies (ranging from 1-10 mW/cm<sup>2</sup>) were observed. Exposures varied from a few min to several hr. During a first series of more systematic experiments in which the intensity of incident radiation was always 10 mW/cm<sup>2</sup> and the duration of irradiation was varied both within and among experiments, there was a small but statistically significant enhancement of reflex transmission during periods of irradiation. However, these effects were not observed in a second more rigorous set of experiments where the incident power density was increased to 20 mW/cm<sup>2</sup>, and all exposure and control periods were uniform (30 min duration).

Temperature control proved to be inadequate in the second series of experiments, and an apparent within-period effect observed during these experiments might be attributable to temperature changes. The results appear to indicate that continuous microwave irradiation has no effect other than thermal on synaptic transmission; however, the experiments were not designed to test the effects of pulsed or modulated microwave fields. (12 refs.)

- 4845 PROSPECTS FOR EXPANSION OF INDUSTRIAL AND CONSUMER USES OF MICROWAVES. (Eng.) Osepchuk, J. M. In: *Fundamental and Applied Aspects of Nonionizing Radiation*. Michaelson, S. M.; Miller, M. W.; Magin, R.; Carstensen, E. L., eds. (New York: Plenum Press): pp. 411-432; 1974.

The present trends in industrial and consumer uses of microwaves were surveyed to assess potential hazards of microwave radiation. The interest in the microwave portion of the electromagnetic spectrum is related to its property of optimum coupling of energy to macroscopic objects of human interest. A survey of sources showed that electron tubes, though mature in technology, will continue to be the main sources of microwave power. However, there will be a large growth in low power solid-state sources for a growing number of low-power applications. The biggest growth market in noncommunication types of microwave applications is in consumer microwave ovens. Numerous industrial applications were reviewed, including those in the forest products, mining, chemicals, and agriculture industries. A few were selected for favorable expectations in market growth. The potential for microwave radiation hazards in this entire field is considered small and under strict government control. The problem of incidental interference, as with cardiac pacemakers was distinguished from direct biologic hazards and was shown to require standards on device susceptibility. With appropriate relation of personnel exposure to emission of microwave sources a high degree of safety is expected for microwave products and systems directed toward industrial and consumer use. (30 refs.)

- 4846 A NEW OCCUPATIONAL DISEASE? --OF DIPLOMATS. (Eng.) Berkley, C. (No affiliation given). *Med. Res. Eng.* 12(3): 3-7; 1976.

The potential radiation hazard produced by the considerable increase in the use of microwaves and radiofrequencies for communications and surveillance is reviewed with particular emphasis on the Soviet microwave bombardment of the U.S. embassy in Moscow. A variety of ailments of embassy personnel including headaches, tics, menorrhea, hematologic disorders, and cancer have been blamed on the microwave irradiation. Although microwaves are known to cause chromosomal abnormalities and hematologic effects, the irradiation of the embassy personnel has not been directly implicated in the development of the

ailments noted. However, there is growing concern among environmentalists and medical scientists that the proliferative use of microwave and other frequencies for communications may pose a potential radiation hazard to the general population. Radiation sources include megavolt transmitters, such as those in the troposphere scatter range and in microwave communications systems, television receivers, and high voltage power lines. A typical case is the microwave communications system used along many U.S. highways. Those who travel these highways regularly, such as truckers, are likely to be exposed to higher than average concentrations of microwave energy. A few milliwatts or even watts in a narrowly directed beam, away from human habitation, will probably not cause an appreciable hazard; however, concern should be given to the cumulative risk effect of a constantly increasing installed voltage. (89 refs.)

- 4847 ANALYSIS OF OCCUPATIONAL EXPOSURE TO MICROWAVE RADIATION. (Eng.) Czerski, P.; Siekierzynski, M. In: *Fundamental and Applied Aspects of Nonionizing Radiation*. Michaelson, S. M.; Miller, M. W.; Magin, R.; Carstensen, E. L., eds. (New York: Plenum Press): pp. 367-377; 1974.

The effects of occupational exposure to microwave radiation are reported. Headaches and fatigue disproportionate to effort showed incidences of 47 and 45%, respectively, among workers exposed to high levels (1-10 mW/cm<sup>2</sup>) of microwave radiation, 30 and 34% in workers exposed to medium levels (hundreds of  $\mu$ W/cm<sup>2</sup> up to 1 mW/cm<sup>2</sup>), and 30 and 30%, respectively, among workers exposed to low levels of radiation (tens of  $\mu$ W/cm<sup>2</sup>) during the first year of work. These complaints disappeared for 2 yr, recurred during the period of 3-5 yr of work, and sometimes reappeared in certain individuals after 5 or 10 yr. Abnormally excessive sweating during the night had a similar time dependence and was found in 68.8% of workers exposed to high levels of microwave radiation, 33.4% of workers exposed to medium levels of radiation, and 22.5% of workers exposed to low levels of microwave radiation during the first year of work. Changes in blood pressure occurred only in workers exposed to high levels of microwave radiation. Diverse white blood cell responses were observed during the first year of work among workers exposed to low levels of microwave radiation; and after 10 yr, 10.5% of the workers in this group showed absolute lymphocytosis that was usually accompanied by monocytosis. Decreased cardiazole tolerance has also been observed in microwave workers. Although the intravenous administration of 500 mg of cardiazole does not provoke any brain wave changes in normal adult males, this same dosage has produced theta waves, theta discharges, spike discharges, and even convulsions in microwave workers with greater than 3 yr of exposure. (30 refs.)

- 4848 EVIDENCE OF MORPHOLOGICAL AND PHYSIOLOGICAL TRANSFORMATION OF MAMMALIAN CELLS BY STRONG MAGNETIC FIELDS. (Eng.) Malinin, G. I. (Biochemical Res. Lab., Res. Foundation of Children's Hosp., Washington, DC 20009); Gregory, W. D.; Morrelli, L.; Sharma, V. K.; Houck, J. C. *Science* 194(4267): 844-846; 1976.

The effect of strong magnetic fields on eukaryotic cells in culture was studied. Cultures of heteroploid L-929 and diploid WI-38 cells frozen to 4.2 Kelvin and exposed for 4-8 hr to 5000 Oe magnetic fields were markedly inhibited in their growth as compared with controls. While controls had to be split at approximately 10-day intervals, there was no need to split experimental cultures for as long as 30-40 days. Moreover, the experimental cultures failed to maintain a consistent monolayer, leaving extensive free surfaces not covered by cells. In cultures grown on cover slips approximately 7 days after exposure to the magnetic field, morphologically distinct cells emerged and were propagated from generation to generation. In the case of L-929 cells, they were characterized by enlarged nucleoli and coarse chromatin, which jointly tended to form a symmetric intranuclear network. The cytoplasm of these cells was filled with tightly packed perinuclear granules that persisted throughout the cell cycle. Although the cytoplasm of WI-38 fibroblasts appeared to be free of granular material, it was enormously elongated. Four weeks after magnetic field exposure, contact inhibition was abolished in flask cultures. The observed transformations appeared to be due to magnetic field effects alone. (9 refs.)

- 4849 THE RESPONSE OF AN AMELANOTIC HAMSTER MELANOMA TO VARIOUS TREATMENT MODALITIES UTILIZING X-RAYS AND HYPERTHERMIA (MEETING ABSTRACT). (Eng.) Shupe, R. E. (Dept. Radiation Therapy, Indiana Univ. Sch. Medicine, 1100 West Michigan St., Indianapolis, IN 46202); Hornback, N. B.; Sayoc, E. *Int. J. Radiat. Oncol. Biol. Phys.* (Suppl. 1): 137-138; 1976.

The preliminary findings of a study utilizing hamsters that compared the effects of radiation alone with radiation and the addition of two forms of hyperthermia (microwave and infrared) is described. It was shown that when x-ray treatments alone were used no effects on tumor growth or reduction in tumor volume were noted, indicating a marked radioresistance against the tumor. However, delays in tumor growth were observed in groups treated with hyperthermia alone, and definite decrease in tumor volume was observed in hamsters using combinations of microwave hyperthermia and radiation therapy. Because of the increase in radiosensitivity with the use of hyperthermia (microwave therapy) and resultant greater survival times, this study formed the basis of an ongoing clinical study using combination of hyperthermia and x-ray therapy on patients with advanced cancer. (No refs.)

# CURRENT LITERATURE

Biological Effects Nonionizing Electromagnetic Radiation 1(3), April 1977

- 4850 ENHANCED UPTAKE OF ANTINEOPLASTIC AGENTS PRODUCED BY MICROWAVE-INDUCED TUMOR HYPERTHERMIA AND DIFFERENTIAL HYPOTHERMIA IN A MURINE GLIOMA (MEETING ABSTRACT). (Eng.) Sutton, C. H. (Dept. Neurological Surgery, Univ. Miami Sch. Medicine, Miami, FL 33152); Olinger, R.; Collazo, L. *Cryobiology* 13(6): 660; 1976.

An experimental model was devised to study the enhanced uptake of antineoplastic agents by microwave-induced hyperthermia and differential hypothermia in brain tumors. C57BL/6 mice were inoculated subcutaneously in both flanks with an experimental murine glioma, the Zimmerman ependymoblastoma. Microwave irradiation at 2450 MHz was employed to heat one flank tumor in each animal to 40, 41, or 42°C, while the remainder of the animal was cooled to 28°C by differential hypothermia. Tracer doses of either [<sup>3</sup>H]cytosine arabinoside or [<sup>3</sup>H]methotrexate were injected intraperitoneally. When concentrations of these agents were measured in heated and unheated tumors, and in other tissues, it was found that peak plasma concentrations of both agents were reached after 30 min. The greatest uptake of each agent during a 45-min period was obtained by heating tumors to 41°C. With both agents, the peak plasma concentrations achieved were two to three times greater in hypothermic than in normothermic mice. Higher concentrations were achieved in heated tumors using cytosine arabinoside than were achieved with methotrexate. These studies confirmed that the distribution of antineoplastic agents can be affected by temperature gradients. They demonstrate an enhanced accumulation of antimetabolites selectively in microwave-heated tumors in the presence of body-core hypothermia. It is concluded that microwave heating of tumors to 41°C for periods of 30-45 min after the parenteral administration of antineoplastic agents may prove beneficial in the chemotherapy of neoplasms that are sensitive to those agents. (No refs.)

- 4851 PRIMATE-PERFORMANCE ASSESSMENT FOLLOWING 3.2-GHZ EXPOSURES. (Eng.) Farrer, D. N.; Yochmowitz, M. G.; Jaeger, R. J.; Allen, S. J.; Wolfe, T. L. (USAF Sch. Aerospace Medicine, Aerospace Medical Div., Brooks Air Force Base, TX 78235). 14 pp., 1976. [available through the National Technical Information Service, Washington, D.C., Document No. AD A023495].

Performance data were obtained from two rhesus monkeys (*Macaca mulatta*) exposed to pulsed nonionizing electromagnetic radiation to assess possible performance decrements that might result in humans exposed to average power densities of about 1 mW/cm<sup>2</sup> during future airborne radar operations. The monkeys were exposed for 3 hr/day for 7 days to 3.2-GHz radiation (average transmitter power output of 200 W), which was modulated with square wave pulses (pulse width of 50 microsec) at a frequency of 4000 pulses/sec. The animals were evaluated in terms of their

ability to use a control stick to maintain an equilibrium platform in a level position in the pitch axis. A comparison of their performance (as measured by the root-mean-square value of platform position) with that of eight control animals in a similar experiment revealed no decrement in performance as a result of the radiation exposure. Ophthalmic examinations completed 22 mo postexposure showed no abnormalities in the exposed animals. The level of radiation energies in this experiment was about 50 times higher than that expected for worst-case crew exposures during airborne radar operations. (13 refs.)

- 4852 ELF ELECTROMAGNETIC FIELD EFFECTS ON LIFE FORMS--BIBLIOGRAPHY. (Eng.) Formanek, V. C. (IIT Res. Inst., 10 West 35 St., Chicago, IL 60616). 181 pp; 1976. [available through National Technical Information Services, Washington, DC, Document No. AD-A023 094].

Four hundred references, many with accompanying abstracts, are contained in this bibliography of the world literature on the biologic effects of extremely low frequency electromagnetic fields. The bibliography emphasizes the following areas: (1) the biologic effects of alternating current (AC) electric and magnetic fields between 45-75 Hz; (2) the alpha-rhythm interaction of AC electric and magnetic fields between 1-15 Hz; (3) AC electric and magnetic field influences on patients with cardiac pacemakers; and (4) behavioral influences, such as, migration, orientation, and sensing-detection. Radiofrequency studies involving modulation frequencies in the 45-85 Hz region are also referenced. In addition, representative samples from the Eastern European literature are included. (400 refs.)

- 4853 STOMATAL RESPONSE TO MICROWAVE INDUCED THERMAL STRESSES. (Eng.) Barthakur, N. (Dept. of Agricultural Physics, Macdonald Campus of McGill Univ., Ste. Anne De Bellevue, Quebec, Canada HOA 1C0). *J. Microwave Power* 11(3): 247-254; 1976.

The stomatal responses of bean and water hyacinth leaves to microwave induced thermal stress was studied. Attached leaves of plants were heated inside a closed-circuit wind tunnel by microwave radiation at a frequency of 2450 MHz. The power density at the leaf surface could be varied from 0-200 mW/cm<sup>2</sup> with an oval-field applicator. Attached bean leaves responded to thermal stresses induced in darkness by lowering equilibrium leaf temperatures between 2-10°C in still air. The lowering of equilibrium leaf temperatures of exposed water hyacinth plants in darkness was even higher than 10°C in still air. The same behavior was also observed for leaves that were placed in an air stream. The observed phenomenon is explained as transpirational cooling when stomates are opened in darkness in response to absorbed microwave radiation and high leaf temperatures. (13 refs.)

- 4854 MICROWAVES SCORE TKO IN FIGHT AGAINST CANCER. (Eng.) Guy, A. W. (No affiliation given). *Microwaves* 15(9): 14, 16; 1976.

The use of microwave radiation for localized heating, either to kill malignant tumors or to make them more susceptible to X-ray therapy, is reviewed. In a study conducted at New York's Montefiore Hospital and Medical Center, the use of a newly developed microwave localized heating system resulted in a complete eradication of tumors and a 100% survival rate in a study employing six groups of mice; each group contained 12 tumor-bearing animals. The microwave device was a closed loop microwave generator operating at 2.45 GHz, and it featured a thermometer that was placed into the tumor. Some researchers caution, however, that the thermometer's presence in the test tumor could, in itself, change the heating pattern within the tumor and contribute to temperature non-uniformity. If heating is not sufficiently uniform, severe damage to normal tissue might occur in local heat spots; in inadequately heated regions, tumor growth might be enhanced. An alternative microwave heating device that produces a uniform ( $\pm 0.1^\circ\text{C}$ ) front-to-back temperature profile within the tumor has been proposed. The method reduces temperature gradients by surrounding a tumor with a material (bolus), similar in composition to the tumor tissue. Because the temperature gradient is distributed over a larger volume, a smaller temperature differential exists in the encapsulated tumor. Although the Montefiore study did not employ bolusing, it is pointed out that the 100% cure rate achieved in that experiment cannot be ignored. It is proposed that microwave radiation be used to complement X-rays and chemotherapy. This proposal is supported by a theory that contends X-rays fail to kill about 2-3% of hypoxic cancer cells. By heating the entire tumor with microwave radiation, some of these cells would become oxygen carrying and therefore susceptible to killing by X-rays. (No refs.)

- 4855 THE EFFECTS OF ELECTROMAGNETIC FIELDS ON THE NERVOUS SYSTEM. (Eng.) Chou, C. (Dept. Electrical Engineering, Univ. Washington, Seattle, WA 98105). *Ann Arbor, MI: University Microfilms International*, 76-17,430, 1975, 115 pp.

A series of experiments were performed *in vitro* to identify the effects of electromagnetic field radiation on the nervous system. In the first experiment, the effects of electromagnetic fields on the compound action potentials of both myelinated and unmyelinated nerves were studied. Isolated frog sciatic nerves, cat saphenous nerves, and rabbit vagus nerves and superior cervical ganglia were exposed to 2450 MHz microwave radiation at a constant temperature in an S band waveguide exposure system. The tissues were stretched through the waveguide either parallel or perpendicular to the electric field of the transverse electromagnetic mode. Compound action potentials of the nerves were recorded before, during, and after microwave irradiation. The results showed no effect other than thermal on the conduction characteristics

of nerves and muscles at specific absorption rates of 0.3-1500 W/kg for continuous wave and 0.3-220 kW/kg peak for pulsed fields. No direct field stimulation or dependence on field polarization was observed during the irradiation. In the second experiment, the effects of electromagnetic fields on muscle contraction were studied. Rat diaphragm muscles were isolated and exposed to 2450 MHz microwaves at a specific absorption rate from 0.3-1500 W/kg for continuous wave and pulsed waves of 0.3-220 kW/kg peak for pulses of 1-10  $\mu\text{sec}$  width. The results showed: (1) no change in amplitude and time course of single switch tensions as long as the temperature was kept constant, (2) a high power effect reproducible by changing the solution temperature, (3) no effect on tetanic contraction, and (4) no direct stimulation of muscle by microwave fields. In the final experiment, the mechanisms of the microwave auditory effect were investigated. The oscillation frequency of cochlear microphonics in the guinea pig skull induced by microwave radiation was compared with the oscillation frequency induced by laser pulses, as well as the bone-conducted acoustic stimuli provided by a piezoelectric crystal. A 50 kHz frequency was recorded for all three sources. Since the laser and piezoelectric crystal pulses provided only a mechanical disturbance to the skull, it was concluded that the microwave pulses also produced a mechanical disturbance. It is suggested that the mechanical disturbance was due to the thermal expansion pressure generated in the head. Additional research is necessary to further elucidate the microwave auditory effect. (70 refs.)

- 4856 TRANSIENT EFFECTS OF LOW-LEVEL MICROWAVE IRRADIATION ON BIOELECTRIC MUSCLE CELL PROPERTIES AND ON WATER PERMEABILITY AND ITS DISTRIBUTION. (Eng.) Portela, A.; Llobera, O.; Michaelson, S. M.; Stewart, P. A.; Perez, J. C.; Guerrero, A. H.; Rodriguez, C. A.; Perez, R. J. In: *Fundamental and Applied Aspects of Nonionizing Radiation*. Michaelson, S. M.; Miller, M. W.; Magin, R.; Carstensen, E. L., eds. (New York: Plenum Press): pp. 93-127; 1974.

Microwave radiation effects on passive and dynamic electrical properties and on cell water parameters were studied in muscle cells from muscles of the South American frog *Leptodactylus ocellatus*. Microwave exposure of 10 mW/cm<sup>2</sup> for a period of 120 min produced transient changes in membrane resistance, membrane capacitance, and the space constant. The electrical parameters related to the excitation and propagation of the action potential, the maximum rate of rise  $V_{\text{max}}$  and fall  $V_{\text{min}}$  of the action potential, and the limiting membrane conductances ( $g_{\text{Na}}$  and  $g_{\text{K}}$ ) were transiently altered. In addition, the peaks of sodium inward and potassium outward ionic currents, the net ionic charge accumulation per action potential, and the propagation velocity of the action potential were transiently altered. The water membrane permeability and the fraction of osmotically available cell volume were also transiently altered.

An analysis of these parameters revealed that the transient changes evoked by microwave radiation are larger in muscle cells from "winter frogs" than from "summer frogs." Seasonal differences in the observed transient microwave radiation effects were analyzed. It was concluded that microwave exposure to 10 mW/cm<sup>2</sup> did not produce permanent effects on electrical and cell water parameters. (32 refs.)

- 4857 DECREASE OF ACETYLCHOLINE RECEPTOR SYNTHESIS IN MUSCLE CULTURES BY ELECTRICAL STIMULATION. (Eng.) Shainberg, A. (Dept. of Life Sciences, Bar-Ilan Univ., Ramat-Gan, Israel); Burstein, M. *Nature* 264(5584): 368-369; 1976.

The effect of electrical stimulation on acetylcholine receptor synthesis by chick muscle cultures was investigated. Six-second (sec) trains of 1 msec square wave pulses with an interval between pulses of 200 msec were delivered to cultures every minute at a potential of 20 V. Pulse polarity was alternated for each train to prevent polarization. When the muscle cultures were stimulated electrically, the amount of acetylcholine receptors, as measured by labeled  $\alpha$ -bungarotoxin binding, was reduced considerably in comparison with controls or tetrodotoxin-treated cells. There was no decrease in the amount of acetylcholine receptors in the presence of the protein synthesis inhibitor cycloheximide, suggesting that the electrical stimulation/sec did not inactivate the receptors. To measure the effect of electrical stimulation on receptor synthesis, existing cholinergic receptors were saturated with unlabeled  $\alpha$ -bungarotoxin, and the rate of appearance of new receptors was measured by the binding of radioactive  $\alpha$ -bungarotoxin after various periods of stimulation. Electrically stimulated cultures bound much less <sup>125</sup>Iodine-labeled  $\alpha$ -bungarotoxin than did control or tetrodotoxin-treated cultures, suggesting that the decrease in  $\alpha$ -bungarotoxin binding as a result of electrical stimulation was due to a partial suppression in receptor synthesis rather than an inactivation of existing acetylcholine receptors or an increase in the rate of their turnover. Furthermore, since total protein synthesis and nucleic acid synthesis in stimulated cultures were similar to those in controls, the effect of electrical stimulation on acetylcholine receptor synthesis appeared to be specific rather than general, affecting the receptor synthesis machinery. (17 refs.)

- 4858 SOME CONSIDERATIONS CONCERNING THE USE OF MAGNETRON GENERATORS IN MICROWAVE BIOLOGICAL RESEARCH. (Eng.) Reno, V. R. (Naval Aerospace Medical Res. Lab., Bureau of Medicine and Surgery, Pensacola, FL 32512). 13 pp; 1975. [available through National Technical Information Services, Washington, DC, Document No. AD A013329].

Microwave fields produced for biologic studies by magnetron generators and traveling wave tube genera-

tors under different operating conditions were characterized. The field produced by the magnetron source operating at a frequency of 2450 MHz was 100% amplitude modulated (at a frequency of 120 Hz) due primarily to the unfiltered power supply used in the unit. The field generated by the traveling wave tube generator was not modulated to a significant degree. Measurements of the magnetron field taken with a National Bureau of Standards (NBS) sensor (electric energy density meter) and a Narda Microwave Corporation broadband isotropic radiation monitor showed that the latter instrument, which had a relatively slow response, tended to obscure field variations detected by the NBS instrument, which had a fast dynamic response. Field measurements during a simulation of microwave pulsing with the magnetron (pulse duration of 100 msec were made while the average output power per pulse was varied over the maximum-to-minimum obtainable range of 4.5 to 1 and indicated that the waveform was different depending on the average power level. Interpulse variations in waveform and in the time of pulse onset were also present at each power level except at maximum power where the pulse characteristics appeared more consistent. Thus, the microwave field incident on an experimental animal can differ depending on both the generator and the conditions of its operation, and these differences may not be apparent if the field is described only in terms of average power. (8 refs.)

- 4859 THE EFFECT OF CONTINUOUS EXPOSURE TO LOW FREQUENCY ELECTRIC FIELDS ON THREE GENERATIONS OF MICE: A PILOT STUDY. (Eng.) Marino, A. A. (Veterans Admin. Hosp., Irving Avenue and University Place, Syracuse, NY 13210); Becker, R. O.; Ullrich, B. *Experientia* 32(5): 565-566; 1976.

Three successive generations of Ha/ICR mice were studied to assess the possible impact of the continuous presence of a low frequency electric field. Mice were allowed to mate, gestate, deliver, and rear their offspring in a horizontal 60 Hz electric field of 100 V/cm. At maturity, randomly selected individuals from the first generation were similarly allowed to mate, gestate, deliver, and rear their offspring while being continuously exposed. Randomly selected mice from the second generation were then mated to produce the third generation. A parallel procedure was followed for a group of mice raised for three generations in a 60 Hz vertical electric field of 150 V/cm and for the control group raised for three generations in an ambient electric field. In the first generation, males and females reared in both the horizontal and vertical electric fields were significantly smaller than controls at 35 days postpartum. Larger depressions in average body weight were seen in the second generation at 35 days postpartum, while at 10 wk postpartum, the differences between the experimental and control weight narrowed considerably. A large mortality rate (mean = 46.5%) occurred in the second and third generation vertical field mice during the 8-35 day postpartum

period. This was possibly due to the greater intensity of the vertical field. In addition, in the vertical field experiments, a relatively constant dorsi-ventral exposure vector existed, particularly for the central nervous system, regardless of the movement of the mice. The increased mortality of the vertical field exposed mice may indicate the existence of a directionally sensitive sensing mechanism within the mouse which initiated a response proportional to the time the electric field existed along the dorsi-ventral axis. The authors recommend further studies to explore the basic causative factors for the observed effects. (8 refs.)

0000 PROCEDURES FOR STUDYING THE ACTION OF ELECTROMAGNETIC WAVES OF RADIO-BAND FREQUENCY IN OCCUPATIONALLY EXPOSED INDIVIDUALS. (Rus.) Gabovich, R. D. (A. A. Bogomolets Medical Inst., Kiev, USSR); Zhukovskii, O. M. *Gig. Tr. Prof. Zabol.* (10): 26-29; 1976.

The light and color sensitiveness of the eye was examined in 25 workers occupationally exposed to centimeter waves with intensities of 235-370 mW/cm<sup>2</sup>, in 22 workers exposed to electromagnetic fields with intensities of 10-50 mW/cm<sup>2</sup>, in 19 workers exposed to reflected electromagnetic waves with intensities of up to 10 mW/cm<sup>2</sup>, and in 25 control subjects. The daily exposure time was 60-90 min. A highly significant increase was observed in the color discrimination thresholds for blue, green, and especially for red, and in the temporary light sensitivity threshold in the first group compared with the control. The second group showed a significant increase in the color discrimination thresholds but not in the light sensitivity. No significant difference was found between the third group and the control. However, the incidence of increased red discrimination threshold was 15.8% versus 9.1% in the control. The changes observed intensified with increasing period of employment in all groups. (4 refs.)

4861 BIBLIOGRAPHY OF REPORTED BIOLOGICAL PHENOMENA ('EFFECTS') AND CLINICAL MANIFESTATIONS ATTRIBUTED TO MICROWAVE AND RADIO-FREQUENCY RADIATION: COMPILATION AND INTEGRATION OF REPORT AND SEVEN SUPPLEMENTS. (Eng.) Glaser, Z. R.; Brown, P. F.; Brown, M. S. (Naval Medical Research Inst. Detachment, Naval Surface Weapons Center, Dahlgren Lab., Dahlgren, VA 22448). 185 pp; 1976. [available through the Naval Medical Research & Development Command, Bethesda, MD 20014].

More than 3,700 references on the biologic responses to radiofrequency and microwave radiation, published up to May 1976, are included in this bibliography of the world literature. Particular attention has been paid to the effects of nonionizing radiation on man at these frequencies. Soviet and East European literature is included in detail. This report is a compilation and integration of seven bibliographies prepared previously by the Naval Medical Research Institute, Dahlgren Laboratory, Dahlgren, Virginia. (3,700 refs.)

4862 SUPERCONDUCTIVITY--A POSSIBLE MECHANISM FOR NON-THERMAL BIOLOGICAL EFFECTS OF MICROWAVES. (Eng.) Cope, F. W. (Biochemistry Lab., Naval Air Development Center, Warminster, PA 18974). *J. Microwave Power* 11(3): 267-270; 1976.

The evidence pointing to superconductivity as a possible mechanism for nonthermal biologic effects of microwave radiation is reviewed. Superconduction is the passage of electron current without generation of heat and therefore with zero electrical resistance. Although it has not been demonstrated experimentally, it has been predicted that superconduction should occur in organic materials at room temperature and above, as it occurs in certain metals. Biologic phenomena, difficult to understand in terms of classical physical-chemical mechanisms, can be explained by superconductive mechanisms. These include the abrupt changes observed in rates of metabolism of growing tissues caused by magnetic fields of 50-150 G; the ability of birds, insects, snails and possibly man to detect very low magnetic fields (0.5-0.1 G), and the observed nonlinear Arrhenius plots of these processes. The hypothesis of biologic conductivity has been strengthened by experimental evidence for superconductivity in bile acids at temperatures as high as 277°K. It was found that abrupt changes in magnetic susceptibility occurred as a function of temperature and magnetic field. Other studies showed that current through thin pyrolyzed carbon films was a periodic function of magnetic field for fields of 0.1 G and below. Only superconductive tunneling can explain this phenomenon. Subsequent studies showed that microwave irradiation of these carbon films at room temperature caused steps in the voltage-current curves, as experimentally observed in metallic junctions with two-electron superconductive tunneling. It is concluded that since the microwave effect on two-electron superconductive tunneling in metals has been used as a sensitive detector for microwaves, the same might serve as a sensitive nonthermal mechanism for the biologic actions of microwaves. (29 refs.)

4863 MICROWAVE OVENS. (Ger.) Roehl, D. (Kreiskrankenhaus Main-Taunus, 6232 Bad Soden, Kronbergerstr. 36, W. Germany). *Dtsch. Med. Wochenschr.* 101(18): 721; 1976.

The possible health hazards of microwave ovens and the possible contamination of food prepared in such ovens are discussed. There are presently no data on any harmful effect of foods prepared in microwave ovens. The mean radiation density at 5 cm distance from the microwave oven is limited to 5 mW/cm<sup>2</sup>, versus a tolerance of 10 mW/cm<sup>2</sup> for whole-body irradiation. Microwave ovens satisfying the safety standards do not represent a biologic hazard for their operators. Since pacemakers, not encapsulated in a metal casing, may be disturbed even by a radiation density as low as 10 mW/cm<sup>2</sup>, patients with pacemakers should avoid microwave ovens. (3 refs.)

# CURRENT LITERATURE

Biological Effects Nonionizing Electromagnetic  
Radiation 1(3), April 1977

- 4864 EVALUATING OPHTHALMOLOGIC CHANGES IN PERSONS EXPOSED TO MICROWAVES. (Rus.) Artamonova, V. G. (Inst. of Hygiene and Medicine, Leningrad, USSR); Samorodova, L. M.; Saikina, A. S. *Gig. Tr. Prof. Zabol.* (10): 24-26; 1976.

Ophthalmologic changes were studied in 269 persons occupationally exposed to radiofrequency microwaves with intensities not exceeding 10 mW/cm<sup>2</sup>, and in 245 non-exposed control subjects aged 22-40 yr. The exposed persons were under 40 yr old, and the period of employment was 5-23 yr in 78.4%. Pruritus of the eyelids, lachrymation, and blepharitis were diagnosed in four exposed persons. Reduced visual acuity due to anomalous refraction was diagnosed in 17.8% of the test group, and in 21.6% of the control. Changes in the fundus of the eye were found in 6 exposed persons, and in 10 control subjects. Biomicroscopic examinations revealed turbidity of the crystalline lens in 70.2% of the exposed persons, and in 82.4% of the control. The changes were bilateral in most cases in both groups. There was no relationship between the incidence of turbidity and the period of employment. The findings indicate no significant differences between the exposed group and the control. (11 refs.)

- 4865 POSSIBLE INFLUENCE OF ATMOSPHERIC ELECTRICITY ON WELL-BEING. (Ger.) Reitner, R. (Institut fuer Atmosphaerische Umweltforschung, Garmisch-Partenkirchen, W. Germany); Scheld, K.; Zoebis, E.; Wanner, H. U.; Fischer, G.; Land, S. *Klima Kaelte Ing.* 4(11): 65-68; 1976.

An interview with investigators concerned with the possible effects of atmospheric electricity on human health is presented. Certain investigators doubt that atmospheric electricity has any effect, either beneficial or hazardous, on humans. However, others recommend that electric field generators be installed in large office rooms to generate a constant field with superimposed square-wave impulses of 10 Hz at stochastic intervals. They claim that such a field would have a positive effect on the well-being, performance, and mental processes of workers. The effect, however, varies among individuals. Screening humans from atmospheric electricity has been shown to cause a reduction of fat deposits and an increase in the water content of tissues. (No refs.)

- 4866 DETERMINATION OF EXPOSURE TO ELECTRIC FIELDS IN EXTRA HIGH VOLTAGE SUBSTATIONS. (Eng.) Loevstrand, K. G. (The Research Inst. of Electricity, Husbyborg, S-755 90 Uppsala, Sweden). *Scand. J. Work Environ. Health* 2(3): 190-198; 1976.

The physical parameters of electric field strength, capacitive current, and electrical discharge related to extra high voltage were studied to determine the occupational exposure of personnel to electric fields in substations and to relate the results to

health effects. A capacitive probe was constructed to measure the electric field strengths at the ground and on top of the head of a man (1.8 m in height) in a 400-kV substation. The symmetric dipole probe was constructed with flat rectangular electrodes placed at opposite sides of a shielding metal case, which contained the electronic components. The circuit consisted of a transient protection device, current shunt resistance, a two-stage voltage amplifier, and a rectifier. Electric field strengths were measured with the dipole at 1.8 m height in a 400 kV-substation. The values agreed, within 30%, with the values reported in similar Soviet studies. To measure the internal distribution of the capacitive current to man, a dummy was built and painted with a semi-conducting paint with a surface resistivity of about 1,000 ohms/square. The capacitive current distribution to a person in an electric field was measured with the dummy at two different places in the substation with different field strengths at the ground, 8.6 kV/m and 18 kV/m, respectively. The capacitive current in the dummy in various positions (arms up, arms down, etc.) ranged from 11  $\mu$ A to 89  $\mu$ A at the 8.6 kV/m field strength. The exposure to electric field strength is recommended for use as the single parameter of stress related to extra high voltage. The constructed instruments can measure exposure, and correlate analysis made by medical investigators with any observed health deviations. (17 refs.)

- 4867 ELECTROMAGNETIC FIELDS BY HENRYK MIKOLAJCZUK (BOOK REVIEW). (Pol.) Mika, T. (No affiliation given). *Wiad. Lek.* 29(1): 71-72; 1976.

In a generally descriptive manner without supplying data, a book dealing with the effects of electromagnetic radiation on the physical properties and biophysical aspects of the human and animal organism is reviewed. The review contains information about natural and artificial sources of electromagnetic radiation, dosimetry methods, pertinent equipment, and the effect of force fields on matter. It also touches on dispersal of electromagnetic energy, protective measures, exposure, control, domestic and foreign legally permissible intensities, and the presence of electromagnetic radiation in occupational environments. Penetration and absorption of radiation energy as well as electric conductivity of biologic materials are mentioned. The demodulation of electric processes in the cell membranes as the result of electromagnetic radiation is also discussed. Regulatory systems of live organisms, their positive or negative reaction, and their organ sensitivity to the radiation are pointed out. Pathologic changes due to radiation, based on experimental data, and disease syndromes in exposed individuals are indicated. A discussion of the biologic hazards in man exposed to electromagnetic radiation concludes the book review. The publication is considered to be valuable from the standpoint of popularizing knowledge of electromagnetic radiation risks in contemporary life and in the occupational environment. (No refs.)

- 4868 MICROWAVE RADIATION. (Pol.) Bogucka, A.  
(No affiliation given); Bogucki, J. *Ochr.  
Pr.* (10): 7-8; 1976.

The harmful effects of human exposure to an electromagnetic high frequency field (microwave radiation) are discussed. Pathophysiologic changes occur only after an appropriately long exposure time. The main effect is a thermal one, which causes the temperature to rise in the affected tissues. Depth of penetration depends on the radiation wave length. Although 100 mW/cm<sup>2</sup> attain permissible human temperature of 39°C, lower levels can affect the central nervous system over longer exposure times. The efficiency of wire mesh screens, used to prevent the effect of microwave radiation, can be determined by means of a nomogram. The suppression of electromagnetic waves is calculated upon passage through the wire mesh for variable mesh and wave length parameters. For higher frequencies, sheet metal screens are frequently employed. Individuals most susceptible to microwave radiation suffer psychologic and physical traumata or severe infections. Polish labor legislation differentiates four areas with varying field intensity levels: (1) safe area-field intensity less than 0.1 watt/m<sup>2</sup>, (2) intermediate-0.1-0.2 watt/m<sup>2</sup>, (3) hazardous-2-100 watt/m<sup>2</sup>, and (4) dangerous area-field intensity above 100 watt/m<sup>2</sup>. The length of stay/per day in each zone is legally determined for medically qualified workers. (No refs.)

- 4869 INVISIBLE ENVIRONMENT. (Ger.) Koenig, H. L. (Lehrstuhl fuer technische Elektrophysik, Technische Universitaet Muenchen, Munich, West Germany). *Umsch. Wiss. Tech.* 76(20): 636; 1976.

Highlights of a colloquium on "Bioclimatic Effects of Electrical and Electromagnetic Fields" are presented. Electrical and magnetic fields have biologic effects on humans. Depending on the type of field, its frequency, and on the circumstances of the exposure, such fields may have beneficial or hazardous effects. The effects of electrical and magnetic fields are especially hazardous on fatigued individuals. There is no strict dose-effect relationship. Man-made electrical fields above a certain intensity level cause stress due to the inability of man to have adapted himself to such fields during the past 50-100 yr. Driving simulator tests showed that electrical fields have no effect on the reaction time of the driver, but they reduce the incidence of errors while driving. Even alternating magnetic fields, whose intensity accounts for only 0.1% of that of the magnetic field of the Earth, were demonstrated to influence electrocardiograms. (No refs.)

- 4870 SAFETY FROM MICROWAVE HAZARDS IN USING MICROWAVE POWER EQUIPMENT-AN IMPI POLICY STATEMENT. (Eng.) Anonymous. (International Microwave Power Inst.). *J. Microwave Power* 10(4): 333-341; 1975.

Hazards of microwave radiation are reviewed in relation to exposure standards. Since microwave radiation

has a frequency lower than that of light, it is non-ionizing in nature, and damage of molecules or biologic tissue cannot result from a single absorbed quantum of microwave energy. The basic biologic effects of microwaves underlying exposure safety standards are associated with significant tissue temperature rise, which requires exposure to at least moderate levels of radiation intensity for a substantial exposure duration. Damage from such heat-producing radiation can be in the form of burns, which may be repairable or unrepairable. Exposure to at least 100 mW/cm<sup>2</sup> for extended durations (many min) appears to be required to produce thermal damage. The exposure standard developed by the American National Standards Institute, known as ANSI C95.1, specifies safe unlimited duration whole-body exposure up to 10 mW/cm<sup>2</sup> or a maximum energy density exposure of 1 mW-hr/cm<sup>2</sup> in any 1-hr period. Contrasted with exposure standards are conservative federally regulated emission standards, which specify maximum leakage level at external surface of equipment, such as, microwave ovens. United States standard defines the maximum emission level as 1 mW/cm<sup>2</sup> at 5 cm before purchase and 5 mW/cm<sup>2</sup> at 5 cm when the equipment is operated. The International Microwave Power Institute's voluntary standard on industrial equipment specifies that a maximum emission level should be 10 mW/cm<sup>2</sup> at 5 cm when operated with the minimum load specified by the manufacturer. (11 refs.)

- 4871 ELECTRONIC SMOG AS A POTENTIATING FACTOR IN CARDIOVASCULAR DISEASE: A HYPOTHESIS OF MICROWAVES AS AN ETIOLOGY FOR SUDDEN DEATH FROM HEART ATTACK IN NORTH KARELIA. (Eng.) Zaret, M. M. (No affiliation given). *Med. Res. Eng.* 12(3): 13-16; 1976.

The possibility that nonionizing electromagnetic radiation is a factor in the development of cardiovascular disease is discussed. A Soviet study is cited that analyzed 100 cases of microwave sickness in which clinical follow-up was obtained over a period of 1-10 yr. Of 71 patients with cardiovascular findings, 49 had continuing occupational exposure and 22 did not. Of the 49 patients with continuing exposure, all exhibited progression of the disease. Of the 22 patients whose occupational exposure to microwaves terminated, none recovered, 20 stabilized, and 2 exhibited progression. It was concluded from this study that microwave exposure was a potential contributing factor in the genesis of cardiovascular disease and that in some cases microwave exposure was the precipitating or potentiating factor. To test the Soviet hypothesis that microwave exposure is a contributing factor in the development of heart attack, the World Health Organization has sponsored an epidemiologic study--the North Karelia Project. North Karelia, a region of Finland bordering the Soviet Union, has experienced an unusual increased incidence of heart attack involving a shift toward younger age of onset. In addition, an unexplained increased incidence of cancer has occurred. Microwave irradiation has been implicated in the high incidence of

heart attack in this region, since North Karelia lies directly in the path of a Soviet defense communications system, which includes troposcopic scatter units. The inhabitants are exposed continuously to ground waves and scatter radiation every day of the year. An additional observation, which incriminates microwaves as a major factor in the North Karelia health problem is the increased incidence of sudden death from heart attack that appeared after World War II. As with other delayed radiant energy effects on man, the North Karelia Health problem also exhibited latency, as it did not manifest until after the Soviet radar networks became operational. It is concluded that the North Karelia Project represents a unique opportunity to investigate the potentiating role of microwaves in the evolution of cardiovascular disease. (17 refs.)

- 4872 EFFECTS OF ELECTRICAL STIMULATION ON BONE GROWTH IN VITRO AND ON FRACTURE HEALING (ABSTRACT). (Eng.) de Haas, W. G. (Dept. Surgery, Univ. Calgary, Calgary, Alberta, Canada); Watson, J. *Can. J. Surg.* 19(4): 333; 1976.

The effect of electrical stimulation on bone growth and fracture healing was studied *in vitro* and in a patient with a fracture. The growth of embryo chick tibias was found to accelerate in pulsed magnetic and pulsed electric fields. In osteotomized radii of rabbits subjected to a pulsed magnetic field, an inconsistent acceleration of bone healing was also observed. In a 50-yr-old man with post-traumatic pseudarthrosis of the tibia, treatment in a pulsed magnetic field for 6 wk resulted in bone union 6 mo later. The authors suggest that the use of a pulsating magnetic field to induce an electric field at fracture sites to effect bone healing should have clinical applications. (No refs.)

- 4873 THE EFFECT OF CHOLINERGIC AGENTS ON THE OUTCOME OF ACUTE AFFECTION OF MICE IN IRRADIATION WITH MICROWAVES. (Rus.) Koldaev, V. M. (Vladivostok Medical Inst., Vladivostok, USSR). *Biull. Eksp. Biol. Med.* 81(3): 285-286; 1976.

The effect of cholinolytic and cholinomimetic drugs on the survival of male albino mice irradiated with microwaves (wavelength 12.5 cm, intensity  $62 \pm 5$  mW/cm<sup>2</sup>) over 15-16 min by contact method was studied. The drugs were administered intraperitoneally or subcutaneously immediately after irradiation. The survival in the control amounted to 47-52%. Treatment with pilocarpine (10 mg/kg), proserine (0.05 mg/kg), and cytosine (1-5 mg/kg) resulted in a 1.2-1.3 increase in the survival rate; whereas, other cholinomimetics did not increase the survival rate. Cholinolytics (atropine sulfate, scopolamine hydrobromide, atropen, tetamone, benzohexonium, pachycarpine hydroiodide, azamethonium bromide, and pyrilene) decreased the survival of irradiated mice. The findings indicate the lesion of the parasympathetic region of the nervous system under the influence of high-intensity microwaves. (3 refs.)

- 4874 EFFECT OF ADENOSINE MONOPHOSPHORIC ACID ON OXIDATIVE PHOSPHORYLATION IN THE LIVER DURING PROLONGED EXPOSURE TO MICROWAVES. (Rus.) Rudichenko, V. F. (Inst. of General and Communal Hygiene, Kiev, USSR); Dumanskii, Iu. D. *Gig. Tr. Prof. Zabol.* (10): 51-52; 1976.

The influence of exposure to microwaves (wavelength = 12 cm, intensity 100 or 1,000 mW/cm<sup>2</sup>, 3x40 min/day, 4 mo) on the effect of adenosine monophosphate and triphosphate on oxidative phosphorylation in liver mitochondria was studied in albino rats. After irradiation, the animals received intraperitoneal injections of adenosine monophosphate and triphosphate before decapitation. In the animals exposed to 100 mW/cm<sup>2</sup>, reduction of oxidative phosphorylation, complete regeneration of the activity of the hepatic mitochondria, and increase in the rate of phosphorylation of adenosine diphosphate under the action of adenosine monophosphate were observed. Exposure to 1,000 mW/cm<sup>2</sup> caused more pronounced changes in oxidative phosphorylation. Adenosine monophosphate caused only partial recovery of oxidative phosphorylation in these animals. Adenosine triphosphate, administered to animals exposed to 100 mW/cm<sup>2</sup>, caused no recovery of respiration and phosphorylation. (15 refs.)

- 4875 PRELIMINARY RESULTS USING LOCALIZED CURRENT FIELD HYPERTHERMIA IN ORAL CAVITY CARCINOMAS (MEETING ABSTRACT). (Eng.) Sternhagen, C. J. (Cancer Res. and Treatment Center, Univ. New Mexico, Albuquerque, NM); Doss, J. D.; Day, P. W.; Edwards, W. S.; Doberneck, R. C.; Herzon, F. S.; Powell, T. D.; O'Brien, G. F. *Int. J. Radiat. Oncol. Biol. Phys.* (Suppl. 1): 101; 1976.

A clinical trial was instituted using localized current field (LCF) hyperthermia to treat accessible malignancies uncontrolled by conventional methods. Three previously irradiated patients were treated using both noninvasive and invasive techniques. Radiofrequency current (500 kHz) was used in four treatments. Thermistors, strategically placed within the tumor treatment volumes, controlled and monitored the temperature. Two patients presented with advanced squamous cell carcinoma of the base of the tongue. Each received a single noninvasive LCF treatment with electrode plates. Prior to hyperthermia the first patient had massive obstructing local disease with widespread metastases. The patient became ambulatory with tumor shrinkage; pain was palliated, and there was airway improvement. She expired after a cardiopulmonary arrest on the sixth posthyperthermia day. The second patient, debilitated with advanced local disease prior to LCF, obtained excellent temporary tumor regression and pain palliation. The tumor decreased initially, stabilized for 4 wk, and then increased in size. Methotrexate, 20 mg, intravenously, was given weekly; however, pain, inanition, and tumor growth increased. At 11 wk methotrexate was stopped. The patient expired with progressive disease 15 wk posthyperthermia. The third

patient, a debilitated alcoholic, presented with a rapidly regrowing 3 cm mass in the floor of the mouth, the second local recurrence. Two courses of hyperthermia were given. Tumor regression occurred only after the second course at a higher temperature (44°C). Pain diminished rapidly the first week. The patient gained 19 pounds and was alive and well over 4 mo posthyperthermia. In all cases, the complications, which ranged from mild erythema and mucositis to vesicle formation, chronic mucositis, and ulceration, were related to temperature and duration of treatment. (No refs.)

4876 THE RELATION OF DOSE RATE OF MICROWAVE RADIATION TO THE TIME OF DEATH AND TOTAL ABSORBED DOSE IN THE MOUSE. (Eng.) Rugh, R. (U.S. Dept. Health, Education, Welfare, Public Health Service, Food and Drug Admin., Bureau Radiological Health, 5600 Fishers Lane, HFX-120, Rockville, MD 20852); Ho, H.; McManaway, M. *J. Microwave Power* 11(3): 279-281; 1976.

The effect of graded exposure rates of microwave radiation was studied in relation to both the time of death and the total absorbed dose at death, as

altered by the single variable of dose rate. Six groups of male and female CF1 white mice were irradiated in a microwave waveguide with six levels of forward power, from 4.83-8.56 W mean value. For both males and females, as the forward power was increased, the average absorbed dose rate also increased, while the average time to death decreased by approximately 90%. In male mice exposed to 4.82 W forward power, the average absorbed dose rate was 50.47 mW/g, compared with 125.36 mW/g in male mice exposed to 8.56 W forward power; the time to death was  $\geq 60$  min compared with 7.62 min. Parallel with this was a decrease in the average absorbed dose to death expressed in joules per gram to 31% in the males and 24% in the females between the lowest and the highest exposure rates. For male mice exposed to a forward power of 4.82 W, the average absorbed dose was 181.7 J/g compared with 55.9 J/g in male mice exposed to 8.56 W forward power. The data for both males and females were similar at comparable dose rates. It is concluded that the average absorbed dose cannot be used as the sole criterion of microwave radiation sensitivity, since as the rate of exposure was increased, the absorbed dose in joules per gram and the time to death both decreased. The absorbed dose rate and the duration of exposure must both be determined in any microwave biologic effects experiments. (6 refs.)

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